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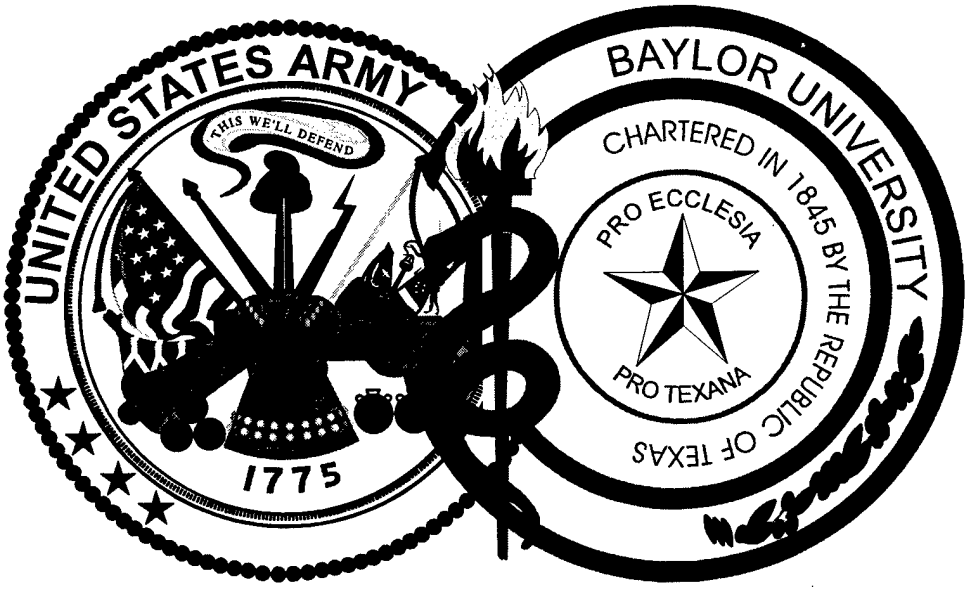
Predictors of Hospital Length of Stay in University Renal Transplant Programs



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Two hundred thousand people have chronic renal disease and 11,000 will receive a renal transplant this year. Renal transplants cost the national medical care system a billion dollars per year and the length of the hospital stay is the best predictor of the total cost of each transplant. The University HealthSystem Consortium (UHC) recognized this expense and initiated a benchmarking study in an effort to identify the best practices. This study used the UHC raw data in an attempt to identify the variables which contributed the most unique variation to length of stay (LOS). If one could identify the variables which contribute to the LOS, the transplant center could concentrate on those variables and bring down LOS while maintaining the quality of care. In the capitated environment of managed care, the length of hospital stay can mean the difference between making or losing money. A hierarchical multivariate regression analysis was performed and the variables *prior transplant experience, total cold ischemic time, routine ICU admission* and *transplant center* were significant at $p < .05$, $F = 29.07$. The transplant center variable contained six discrete variables designating specific centers. The four variables accounted for nearly 25 percent of the unique variation in LOS and the largest portion resulted from the transplant center variable, implying the there may be regional variation. This sample reflects a very strong correlation between total cold ischemic time and LOS which supports the argument in favor of lowering the total cold ischemic time. Further research needs to be done in regional variation and the effects of clinical pathways.

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ABSTRACT

Two hundred thousand people have chronic renal disease and 11,000 will receive a renal transplant this year. Renal transplants cost the national medical care system a billion dollars per year and the length of the hospital stay is the best predictor of the total cost of each transplant. The University HealthSystem Consortium (UHC) recognized this expense and initiated a benchmarking study in an effort to identify the best practices. This study used the UHC raw data in an attempt to identify the variables which contributed the most unique variation to length of stay (LOS). If one could identify the variables which contribute to the LOS, the transplant center could concentrate on those variables and bring down LOS while maintaining the quality of care. In the capitated environment of managed care, the length of hospital stay can mean the difference between making or losing money. A hierarchical multivariate regression analysis was performed and the variables *prior transplant experience, total cold ischemic time, routine ICU admission* and *transplant center* were significant at $p < .05$, $F = 29.07$. The transplant center variable contained six discrete variables designating specific centers. The four variables accounted for nearly 25 percent of the unique variation in LOS and the largest portion resulted from the transplant center variable, implying the there may be regional variation. This sample reflects a very strong correlation between total cold ischemic time and LOS which supports the argument in favor of lowering the total cold ischemic time. Further research needs to be done in regional variation and the effects of clinical pathways.

TABLE OF CONTENTS

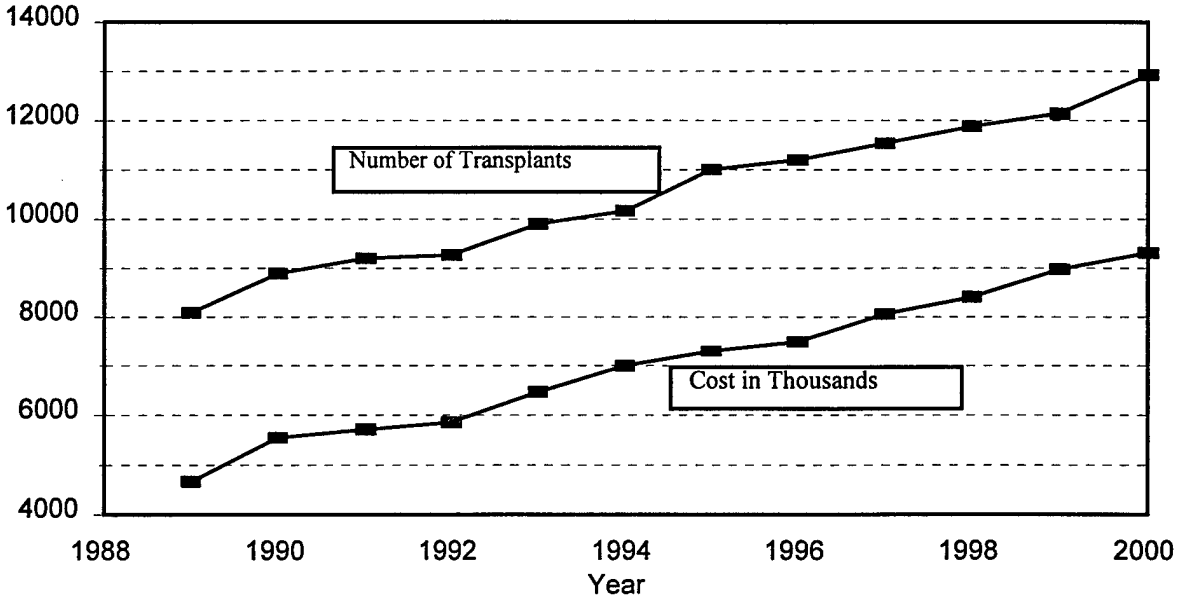
LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

There are 200,000 people in the United States suffering from chronic kidney failure (UNOS 1996). Of those who have chronic kidney failure, 27,000 are waiting for a renal transplant (UNOS 1996). Only 11,000 of the patients awaiting renal transplantation will receive a kidney either from a cadaver, living unrelated donor or through a living related donor (UNOS 1996). Renal transplants are the most common transplant procedure performed in the United States comprising 2.5 times as many as liver, the second most common transplant operation (UNOS 1996). According to a Wall Street Journal article, the average cost (surgery plus after care) of a renal transplant in 1995 was $92,700, bringing the direct cost to the medical system of more than a billion dollars per year (Johnson 1995). These costs are borne primarily though third party insurance especially Medicare (HCFA 1996).

In 1994 alone, Medicare paid over half of all renal transplant costs. The number of Medicare eligible renal transplant patients has nearly doubled in



Note: 1995-2000 are conservatively estimated based on linearity and the assumption of a normal curve. Actual values will be higher due to the Baby Boom reaching Medicare eligibility age (HCFA 1996).

Figure 1. Renal Transplants Sponsored by HCFA

just five years and as the age wave works its way through the health care system, this problem will undoubtedly intensify (see figure 1, HCFA 1996).

Why Study the Renal Transplant Program in the University HealthSystem Consortium and Georgetown University Hospital?

Georgetown University Hospital is a member of the University HealthSystem Consortium (UHC) with an active adult and pediatric renal transplant program since 1976 (Beaulieu 1996). The participating members of the UHC performed nine percent of the 11,000 renal transplants nation wide in 1995.

Given the longevity of the Georgetown program, the large number of renal transplants performed by the UHC and the impact of Medicare/Medicaid changes or of managed and capitated care, this is the perfect time to study length of stay (LOS) in renal transplantation. The results of the study should be valuable and generalizable to the universe of American Academic Medical Centers. Additionally, the demographics and prevalence of certain chronic diseases (diabetes mellitus, chronic hypertension) in the District of Columbia, predisposes the area to a higher number of potential renal transplants.

Patients are generally diagnosed with chronic kidney disease that often leads to renal failure and the need for a kidney transplant. The most common primary diagnosis is diabetes mellitus, which leads to kidney failure in 60 percent of long term diabetics (UNOS 1996). The District of Columbia has a predominantly African-American population which is 3.5 times more likely than a Caucasian population to develop diabetes mellitus in its life time (Andreoli, et al. 1993). Second only to diabetes, uncontrolled chronic hypertension is a key contributor to kidney failure, accounting for 30 percent of transplants. The African-American community also has a higher propensity to hypertension (Andreoli, et al. 1993). The demographic characteristics of the District make it

essential to have adequate, cost effective renal transplant programs available in the coming years.

Georgetown University Hospital provides kidney transplant operations to all District residents regardless of their ability to pay. Managed care's outpatient emphasis has had a significant impact on Georgetown which still has a tertiary care focus. Prospective payment systems such as Medicare, Medicaid and regional HMOs, have shifted the financial risk to the hospital, making it even more necessary to control costs while maintaining the high quality of care. In 1995, 85 percent of Georgetown's renal transplants were Medicare beneficiaries (Beaulieu 1996). Georgetown was also recently awarded a contract for renal transplants from a large national HMO for all of its renal transplant patients in the Washington Metropolitan area, thus adding to the prospective payment pressure.

In addition to managed care pressures, renowned teaching programs such as Georgetown's and others in the UHC, are expensive and often require the hospital to balance between the extra expense of training future physicians (additional labs, longer inpatient hospitalization, overhead costs due to research, etc.) and the insufficient managed care reimbursements. This leaves the hospital in the precarious ethical, social, and financial position of equitably treating all who

come through its doors, dealing with the negative impact of low managed care reimbursements and its mission of graduate medical education and research. All are clearly in its mission statement and appear to be opposed to one another.

A large renal benchmarking study was performed by the UHC in May 1996 (for the 1995 calendar year), which showed that Georgetown had one of the longest lengths of stay for the 33 universities hospitals participating. This is particularly important since LOS is the best predictor of total charges (Gorman et al. 1993). In the capitated world of managed care, total charges and subsequent reimbursement risk is held by the hospital or provider of care. The managed care company can deny charges not within the contract or agreement even if the hospital has already provided the services to the patient. The hospital has three choices: sue the insurance company, approach the patient or write-off the expense. Suing the managed care company is not generally a viable option since they probably have a solid contract and the amount is seldom significant enough to spend months in court with attorneys on both sides. Seeking payment from the patient is illegal (balance billing) in the case of Medicare and anything more than a simple request for collections is not good for public relations. The hospital often absorbs the expense.

Given Georgetown's tertiary focus, high percentage of prospectively paid transplant cases and higher than normal length of stay, it would be ideal to find the significant *predictors* of length of stay. If one could identify these significant predictors, renal transplant programs could concentrate on those predictor variables which account for the greatest amount of unique variation. The programs can then concentrate their streamlining efforts on these variables and decrease the length of stay while maintaining the medical quality of the program. Without these research efforts, hospital systems such as Georgetown's might focus their renal transplant streamlining efforts on the wrong variables and never accomplish the goal of decreasing LOS or total charges. In a capitated environment with the risk shifted back to the hospital, Georgetown and other members of the UHC cannot afford the financial risk of having a LOS beyond that of the reimbursable national norm.

Why is Renal Transplant Length of Stay Important?

The amount of time, or length of stay, that a patient is in the hospital is a well known predictor of the total cost of the surgical experience (Gorman et al. 1993). This is especially true of transplantation surgery, which has many potential complications that can compound the LOS. In recent years, hospitals

have attempted to decrease the amount of time that the patient spends in the inpatient setting, as staying in the hospital can increase the possibility of nosocomial infection along with the total cost of the procedure. Hospitals in capitated environments are occasionally accused of discharging patients before it is medically appropriate, based upon reimbursement concerns rather than medically acceptable standards of care. Sometimes the providers, urged by administrators, set their medical sights on a discharge day based on a diagnosis related group (DRG). The hospital's readmission rate is generally an indicator of whether it is using the correct discharge criteria (Parisi and Meyer 1995). If the readmission rate is higher than normal for that procedure, the providers should look at alternate discharge criteria.

The financial risks incurred by the insurance company and shifted to the hospital have caused both to find ways of decreasing inpatient hospitalization and length of stay. Georgetown and other members of the UHC must decrease the length of stay of their renal transplant patients to satisfy the payers, but do not want to risk decreasing the quality of the transplant experience. By discovering the variables that correlate with, and have predictive power for length of stay, Georgetown could establish baseline performance criteria and decrease

performance variability. Georgetown could then drive down length of stay while maintaining the quality of care. Without this focused research, most managerial attempts to control costs and quality of this medical care will likely fail. The objective of this research will be to determine which of the variables in the UHC benchmarking study account for the most unique variation in LOS, so that hospitals can work on streamlining this variation. By reducing the variation in LOS, hospitals can decrease the LOS, decrease costs and increase quality.

Literature Review

The literature on LOS begins in 1983 with the implementation of the prospective payment system (PPS) by the Health Care Finance Administration (HCFA) (Lanska 1994). The concern over LOS was not initially prompted by clinical indicators, rather by the financial implications of the PPS. During the years when medical care was reimbursed in a fee-for-service (FFS) system, it was to the hospital's advantage to *extend* the length of stay, since it was paid for each test, procedure and day in the hospital. While these additional tests were in the name of *good medicine,* there was no incentive to reduce the number of tests and so they continued. These incentives were radically changed with the introduction of the PPS and capitated payment systems.

Capitation is a method of payment in which the payer offers a fixed amount to purchase a service. In the case of health care, the service is often ill defined but the outcome is not. In this case, the insurance company is simply defraying risk. As the capitated payment concept expanded into contract medicine, the risk was shifted to the providers of health care (Kovner 1995). In the case of medical care, this meant that *if* the treatment and subsequent hospitalization costs are less than predicted, the provider keeps the excess. However, if the hospital is unable to provide that care within the fixed, prearranged amount, the provider must absorb the excess expense, and hence looses money. Suddenly, the incentive to generate tests and keep the patient in the hospital longer was reversed and providers were charged with treating the patient and sending them home as soon as medically or *economically* feasible (Kovner 1995). This caused the entire health care industry to ponder the question of what was an appropriate length of stay for a specific procedure or illness. (Davidhizar 1995).

The articles, papers and reports on length of stay seem to center around high-cost, common admissions for coronary artery bypass grafts, acute myocardial infarctions and obstetrics (Lazar et al. 1995, Chen and Naylor 1994;

Paul et al. 1995). Since organ transplants are much less common, there have been few research studies generated that even mention LOS. It has only been in recent years that insurance companies have begun reimbursement for organ transplants on a capitated basis. Recently, however, managed care companies have been contracting with tertiary care facilities on a fixed price basis, shifting the financial risk of transplant surgery to the provider (Kovner 1995; Kongstvedt 1995; Beaulieu 1996; Penrod 1996). As the number of transplants rise commensurate with the age wave, managed care companies are employing nontraditional methods, even flying patients out of state to a location of low cost, high quality care (Penrod 1996).

Following the implementation of the Tax Equity and Fiscal Responsibility Act of 1983, the Federal Government was able to assign the *acceptable* length of hospital stay based on the diagnosis at the time of discharge. A large statistical study done at Yale University determined 470 mutually exclusive diagnosis-related groups (DRGs). Part of the study was to determine the average length of stay for each of the DRGs. While the survey covered South Carolina, New Jersey and Connecticut, it was clear that geographic variations throughout the United States were not accounted for in the averages (Lutjens 1993). The

purpose of the legislation was to provide an incentive to reduce the hospital LOS, not to justify the current variation in regional medical treatment. While many thought that DRGs would have a dampening effect on LOS, three years after their implementation, Halloran and Kiley (1987) found that the DRG cost weights only explained 5.8% of the variation in LOS. Five years later, Lutjens (1992) found that DRG cost weights only accounted for 1% of the unique variation. The apparent savings brought about by the implementation of the DRG cost weights had *apparently* been maximized. Finally, Berki et al (1984) asserted that LOS should not be automatically attributed to medical complexity, but rather the non-clinical factors such as *clinical practice patterns*. Ultimately, it appeared that DRGs had an initial impact on LOS which has decreased over time. Berki, et al (1984) may have had an excellent point concerning practice patterns rather than outside influences on the delivery of care. This would imply that the DRG-prescribed LOS is medically sufficient and that the way the staff delivers the care within that time frame dictates the LOS and resource utilization rather than the statistical restrictions.

Severity of the illness within a DRG has been studied by several authors and has met with modest success in accounting for the variation in length

of stay. Horn et al (1985) found that patients grouped by severity level varied even within those groups. Green et al (1987) found that a severity adjustment accounted for only 3 percent of the variation. Iezzoni et al (1988) found that the severity index accounted for only 15.9 percent of the variation when severity score was added to the DRGs. While severity is a piece of the length of stay puzzle, it still accounted for less than 20% of the overall variation in length of stay.

DRGs as a single influence do not seem to account for the variation in length of stay. At best, they account for less than 20% of the observed variation when based on a severity adjusted index. While the Prospective Payment Assessment Commission is discontinuing its efforts to look at nursing intensity adjustments, it has spawned the Agency for Healthcare Policy and Research, which holds that practice patterns and clinical judgment account for a greater share of the LOS. These variables appear promising for future research into LOS.

When organ transplant length of stay is studied in a hierarchical multivariate linear regression model, it is generally done in the context of an independent variable or as a byproduct when comparing the effects of the prospective payment system or clinical pathways (Lanska 1994). Searching MEDLINE and GratefulMed, there were 220 articles referencing length of stay

from 1990-1996 and few used length of stay as the dependent variable when testing hypotheses. The studies focusing on length of stay as the dependent variable have done so to determine their unique contributions to total variation.

Weibrecht (1993), Vergnenegre et al. (1995) and Arndt et al. (1996) used regression techniques to analyze variations in length of stay. None of these studies dealt with organ transplant surgery. Regression models in the literature routinely control for age and sex (Weibrecht 1993, Vergnenegre et al. 1995, Arndt et al.1996, Chen and Naylor 1994), which is a standard epidemiological practice (Oleske 1995). Managed care and, specifically, the implementation of the PPS have fostered concerns regarding the length of stay (Rakich 1992; Kongstvedt 1995). Authors have examined length of stay for specific procedures and diagnoses and often use regression modeling to determine significant variables in the equation for further analysis and refinement (Spatz 1992; Cooper and Emory 1995; Levin et al. 1992).

In the studies using length of stay as the dependent variable, medical journals tend to use strictly clinical variables such as drug protocols, treatments and surgical approaches. The nursing journals often (though not exclusively) focus on early education, discharge planning and the psychosocial aspects of patient care.

In interviews with prominent renal transplant directors, there appear to be two schools of thought with regard to the amount of time that an organ is *on ice.* This is the amount of time the organ is detached from the donor (whether cadavaric or living), submerged in University of Wisconsin (UW) Solution, until attached to the recipient and full perfusion. This phase of the transplantation experience is called the cold ischemic time. Experts are split on whether they believe that the cold ischemic time has an influence on LOS. One group says that the amount cold ischemic time *does not* influence overall length of stay (Penrod; Little 1996). The other group says that cold ischemic time *does* matter (Shaver; Alajani 1996). This controversy presents a good starting point for looking at the transplantation variables. With the large geographic area covered by the UHC hospitals and the protocols that are in place, we should be able to see if there is regional variation in the LOS for renal transplants. This represents another set of variables that can be looked at with the UHC data.

Conceptual Model

When contemplating the potential variables that may influence the length of stay in any surgical experience, three primary areas must be considered: patient demographics, clinical staff experience, and the specifics of the surgical

procedure. Demographic characteristics include, age, sex, cultural beliefs, health status, and social support. Clinical staff experience encompasses the areas of length and quality of training, individual judgment, breadth of experience, hospital clinical guidelines, community continuum of care, and administrative or financial pressures. Specific surgical procedures have unique treatment regiments, procedures, drug, and research protocols, which all influence the length of patient stay. The conceptual model seeks to answer the following questions:

Patient Demographics:

- How old is the patient? Older people tend to require longer hospital stays on average due to either comorbidities, slower healing time or a lack of social support for returning home.
- What is the sex of the patient? Male or female.
- What are the patient's cultural beliefs? Is the patient a person of faith? Do they come from a culture of learned helplessness or self sufficiency? What are their views about hospitals? Are hospitals a place to get well or to die?
- What is the health status of the patient? Are there several interfering comorbidities that have led to the transplant or subsequent complications?

- Does the patient have adequate social support to return home? This is especially important with the elderly and very young patients. If the elderly patient does not have adequate social support, do we need to move them into a sub-acute unit or nursing home?

Clinical Staff

- What are the education and training levels of the clinical staff including nursing school, medical school (residencies and fellowships), and technician training? Have they specialized in this type of patient or are they more cautious because they are unfamiliar with the age specific aspects, etc.
- How does the staff exercise their own judgment? Are they allowed to use their own judgment or is it restricted to a select few? Is their judgment considered conservative or are they more aggressive?
- What is the experience of the staff? Have they performed many, very successful transplants or a few that have not gone well? Do they attribute their poor outcomes to a short LOS or a long LOS?
- Does the hospital have clinical guidelines in place to provide guidance for the staff? If no guidelines exist, how are decisions made? If they are made

exclusively through one person (attending physician) then what is their clinical training, judgment, and experience?

- What kind of discharge planning is taking place? Is the nursing staff doing all of it or is it a multidisciplinary approach? Does it start when the patient enters the hospital or just before they leave? How aggressive is the discharge planning? What is the tone of the planning? Is a hospital somewhere to recover comfortably or the source of nosocomial infection? Is there social support at home?

- What non-clinical pressures are in place? What payment method is being used by the primary payer? Is there a capitated contract in place? If the patient was nearly ready to go home, but not quite, would the staff be swayed by the payment method at all? Is there additional administrative pressure? Are beds tight or is the staff needed elsewhere?

Clinical/Procedural

- What was the procedure or treatment? If a transplant was performed, did it go as planned or were there complications? How serious were the complications and is additional treatment necessary?

- What drug protocols were used pre-op, during and post-op? Are the drug protocols effective or experimental research protocols?
- Is there an established clinical pathway? Are we using the pathway to reduce LOS? Are we revising the pathway at least annually to maintain the state of the art?
- Are any other research protocols in place that would influence the LOS?

All of these variables may contribute to LOS and need to be evaluated. In addition to sex and age the variables in this study are primarily Clinical/Procedural in nature. The remaining variables are fertile ground for future research.

Hypotheses

The working hypotheses for this analysis is a relationship between the length of hospital stay after renal transplant, the dependent variable, and the following independent variables. For a complete list of the independent variables see Appendix A.

1. **Cold Ischemic Time** - This is the cold perfusion pump time or cold storage time. The cold ischemic time begins when the organ leaves the donor's body (whether cadevaric or living) and is either put on a perfusion pump or submerged in Belzer's Solution (also called Wisconsin University Solution). The total cold ischemic time ends when the organ is attached to, and perfused by the recipient. The variable is measured in minutes and is a continuous variable.

2. **ICU Stay post Transplant** - This binary variable indicates whether the patient went to the ICU after transplantation. The variable does not indicate whether the patient *required* ICU level care, rather only that they went to the ICU. This will be important since there are some Medical Centers that send post-transplant patient automatically to the ICU. The variable is coded 1 for ICU stay post transplant and 0 if not.

3. **Centers of Transplantation** - This binary variable designates the center performing the transplant. While not a perfect proxy, if any of the centers are statistically significant, it will give some indication that regional variation needs additional study. Each center is its own binary variable and

the case is coded 1 if the transplant was done at that center and 0 if done anywhere else.

4. **Prior Transplant** - This binary variable indicates whether the patient has had a prior transplant and is coded 1 if the patient *has* had a prior renal transplant and 0 if the patient has not. Depending on the direction and magnitude of the relationship in a simple regression, there are two possibilities. The direction could be negative, indicating that the LOS decreases if the patient has had a prior renal transplant, or positive meaning that the LOS increases if there has been a previous renal transplant. A negative relationship could result from prior experience and knowledge of medications enabling the patient to leave the hospital sooner than other transplant recipients. If the relationship is positive, this could be due to additional comorbidities (rejection episodes) which may have resulted in the new transplant.

5. **Total Operating Room Time** - This continuous variable measures the total amount of time spent in the operating room, from the time the patient enters, until they exit. This variable takes into account anesthesia time and the disruption of organ systems during surgery.

6. **Human Leukocyte Antigen Mismatches** - HLA typing, or tissue typing, is the primary means of determining tissue compatibility in humans. HLA genes determine the type and pattern of proteins found on the surface of all body cells. When an organ transplant takes place, foreign tissue and foreign proteins are introduced into a patient's body. The immune system of a transplant recipient may recognize and reject tissue that carries different proteins. By identifying the HLA antigens of donors and recipients, as well as potential immune response, physicians can determine compatibility between donors and recipients. The higher the number of mismatches, the more likely it is that the organ will be rejected by the recipient, possibly adding to the LOS. There are six binary variables in this group, ranging from "no HLA mismatches" to "six HLA mismatches". The variables are:

   - No HLA mismatches
   - 1 HLA mismatches
   - 2 HLA mismatches
   - 3 HLA mismatches
   - 4 HLA mismatches

- 5 HLA mismatches
- 6 HLA mismatches

7. **Immediate graft function** - Graft function is whether the organ has begun to work after it is perfused. Immediate graft function indicates that it began working while the patient was still in the operating room, prior to closing the incision. The sooner the graft functions, the less likely rejection is and the more likely that the patient will leave the hospital on time. Immediate graft function is a binary variable and is coded 1=yes, the graft did function in the operating room and 0=no the graft did not function prior to leaving the operating room.

The contribution of each unique variable on the total variation accounted for will be assessed while controlling for sex, age, race, drug protocols, donor race, and post operative complications.

The equation below shows the *symbolic* representation of the full hierarchical multivariate regression model to be used:

$$Y_i = B_0 + B_1X_1 + B_2X_2 + \in_1 \ldots$$

Hypothesis 1:

Ha: length of stay $= f$ (cold ischemic time)

Ho: length of stay $\neq f$ (cold ischemic time)

Hypothesis 2:

Ha: length of stay $= f$ (ICU stay post transplant)

Ho: length of stay $\neq f$ (ICU stay post transplant)

Hypothesis 3:

Ha: length of stay $= f$ (transplant center)

Ho: length of stay $\neq f$ (transplant center)

Hypothesis 4:

Ha: length of stay $= f$ (prior transplant)

Ho: length of stay $\neq f$ (prior transplant)

Hypothesis 5:

Ha: length of stay $= f$ (total OR time)

Ho: length of stay $\neq f$ (total OR time)

Hypothesis 6:

Ha: length of stay = f(HLA mismatches)

Ho: length of stay $\neq f$(HLA mismatches)

Hypothesis 7:

Ha: length of stay = f(immediate graft function)

Ho: length of stay $\neq f$(immediate graft function)

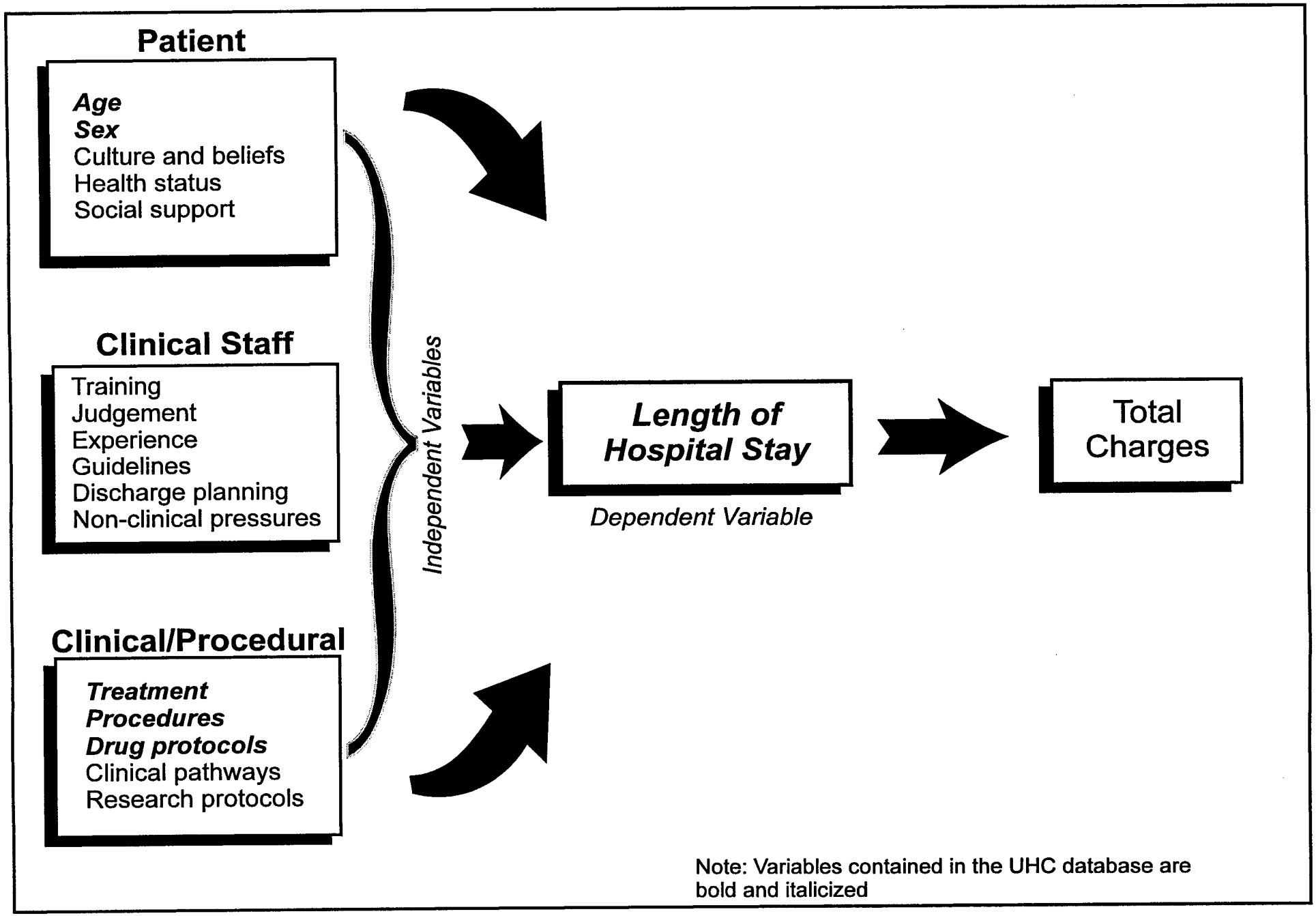


Figure 2. Conceptual Model

Ethics

Data collected in this study was incidental to patient care provided. Patient privacy was protected by the deletion of patient identifiers prior to the evaluator's analysis. Patients consented to the use of specific data for the express purposes of this study. Due to these procedures, there was no possible impact on patient privacy or quality of care.

METHODS AND PROCEDURES

The University HealthSystem Consortium is a voluntary group of university hospitals that pool raw data for the purpose of *collegial comparison.* Thirty-three of the UHC hospitals collected data for a renal transplantation benchmarking study which was been made available for these analyses.

Development of Data

The data used in this study were collected by the University HealthSystem Consortium (UHC) and are restricted to renal transplants performed by UHC members in 1995. Originally there were 217 variables in the data base and 1033 cases. Many of the variables were culled out of the data base through expert opinion (Alijani 1996; Shaver 1996; Penrod 1996) and the resulting

data base was 85 variables. The variables which were culled out, were not thought to contribute or impact renal transplant length of stay and could potentially complicate the analyses.

The original data were not uniformly coded in a useful manner. Several of the proposed variables were mutually exclusive, categorically exhaustive (MECE) and were subsequently recoded into binary or dummy coded variables in preparation for multivariate linear regression analysis. This increased the number of independent variables to 109 and allowed for MECE data sets which could then be compared in a statistical manner. The cases that were missing one or more entry for a variable were purged from the data set which decreased the number of cases from 1033 to 855. This would become a weakness of this study if regional variation were to become statistically significant and be studied in depth. There was no attempt to identify regional centers that did not completely code their patients as the data base indicated. This could be done in future research efforts if indicated.

Thirty-three transplant centers nation-wide participated in this study. The patients reflected in the study were not the whole population of renal transplants in the United States, nor were they randomly or independently

selected to participate in this study. This data set *does* reflect nearly nine percent of the 11,000 renal transplants performed in this country annually. Given the central limit theorem, it is felt that the size of the sample validates its use for statistical analysis.

The original data set was comprised of 1033 records, each containing 217 variables per record. The benchmarking study compared the data on a macro level (descriptive statistics), but were never studied in such a way as to derive and analyze the variable *components* of length of stay. While it is a sample of convenience, it is sufficiently large and diverse that the results should be generalizable to the population. Limitations to this study are largely due to lack of evaluator input to the data set collection effort as the variables are predominantly clinical, are already been collected, and additional data collection is not possible.

A hierarchical multivariate linear regression model was used to evaluate which of the variables in the data set accounted for the greatest unique variation in length of stay. In order to determine which variables in the data set were pertinent to the analysis, the first regression model used all of the variables available as independent variables against length of stay as the dependent variable.

See Appendix A for a complete list of the study variables. A second regression model was developed from the original which used only those variables that showed significance $p < .05$.

A third regression model was derived from these, after holding constant those variables whose R^2 were not significant. The resulting variables constituted the study's final regression model and were: Centers (AB, AZ, CN, GU, KY, VA), automatic post-op ICU stay, prior transplantation experience, and total cold ischemic time.

Validity and Reliability

Validity is measuring the *correct variable* in pursuit of either confirming or denying a hypothesis. Reliability is testing to see if you had consistent measurements of the variable in the formulation of your data set. The validity of the data was tested through the use of expert opinion and through the literature (Alijani 1996; Shaver 1996). This formed the basis for face and content validity. Figure 2, the conceptual model, was derived from the literature, original conceptualization validated through discussion with experienced transplantation surgeons and transplantation coordinators (Alijani 1996; Shaver 1996; Worrell 1996; Penrod 1996).

Reliability of the data collected was assured through detailed written instructions to each transplant coordinator describing the focus of the study and the method of data collection. The questionnaire is contained in appendix B. Those records which were incomplete (containing one or more empty fields) were omitted from this study. While reducing the variability of data measurement, this introduced a certain bias into this study which was considered inconsequential. The variation in data collection centers was not the focus of this study, rather, clinical processes that would affect the length of stay and therefore cost and quality of care (see figure 2, Conceptual Model).

THE RESULTS

The original data set comprised 264 variables encompassing the transplantation experience. From the original expanded data set, 109 were identified by experts in transplantation and analyzed for their unique contribution to the variation in LOS (see appendix A for a complete list of the study variables). Of the 114 variables in the first round of hierarchical multivariate regression, 13 were found to be significant at $p < .05$ and are presented in table 1. These 13 variables were further subjected to multivariate analysis and nine were significant

at $p < .05$ presented in table 2. These nine variables were found to account for nearly 24 percent of the unique variation in LOS ($p < .05$). The variables and their unique contributions to the total variation in LOS are contained in table 3. Figure 3 demonstrates the frequency of *number of day* observations. It is clear that most are clustered down toward the 5 -15 day range, contributing to the 10.6 day mean. Lengths of stay above 30 days are rare, but can have a devastating effect in a capitated environment.

Figure 3. Frequency of Day Categories

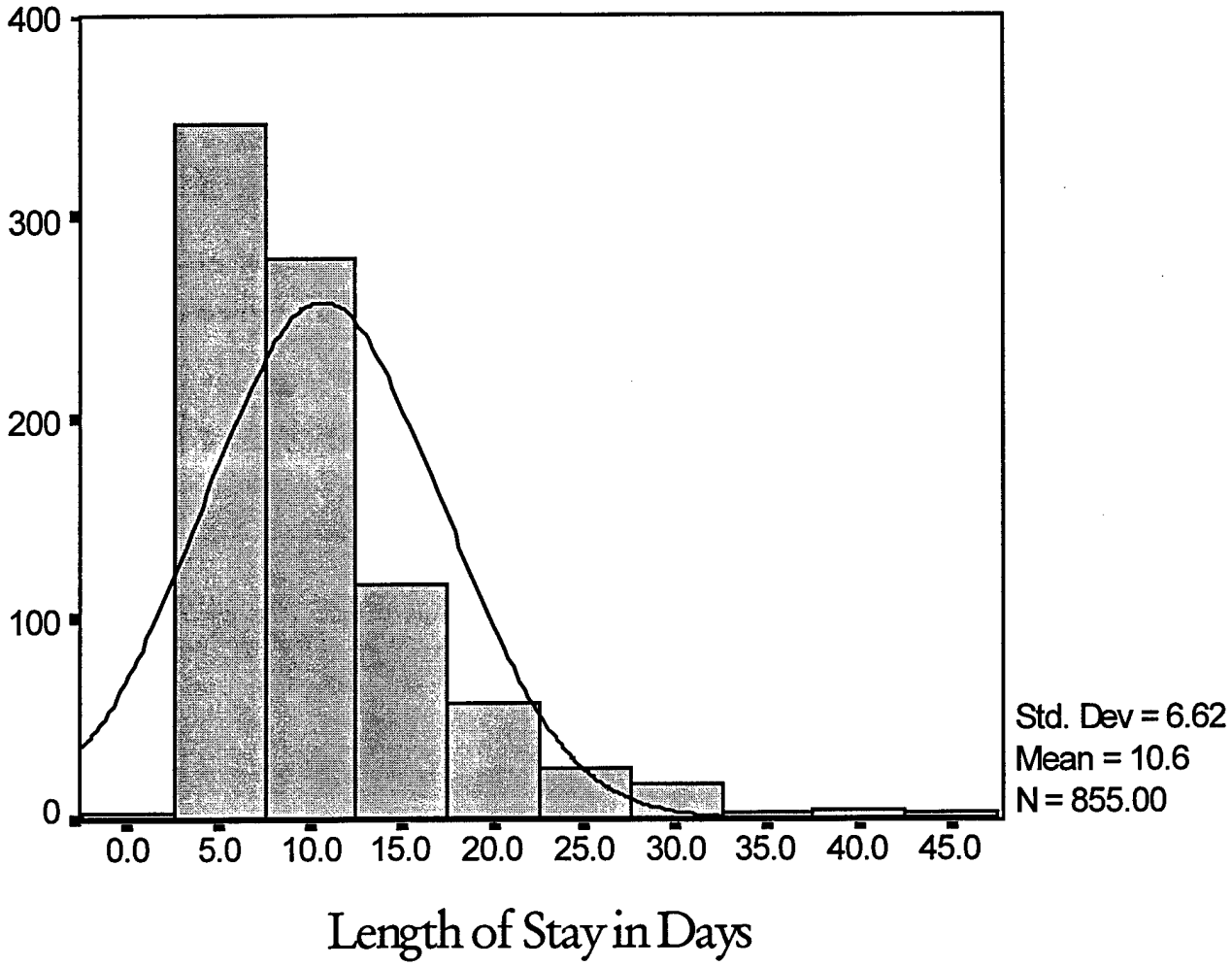


Table 1. Frequency table of length of stay in days

Length of Stay in Days	Statistics		
	Frequency	Percent	Cumulative Percent
.00	3	.4	.4
3.00	6	.7	1.1
4.00	47	5.5	6.5
5.00	95	11.1	17.7
6.00	99	11.6	29.2
7.00	99	11.6	40.8
8.00	69	8.1	48.9
9.00	70	8.2	57.1
10.00	56	6.5	63.6
11.00	52	6.1	69.7
12.00	32	3.7	73.5
13.00	25	2.9	76.4
14.00	23	2.7	79.1
15.00	24	2.8	81.9
16.00	22	2.6	84.4
17.00	23	2.7	87.1
18.00	13	1.5	88.7
19.00	8	.9	89.6
20.00	11	1.3	90.9
21.00	15	1.8	92.6
22.00	11	1.3	93.9
23.00	7	.8	94.7
24.00	5	.6	95.3
25.00	5	.6	95.9
26.00	4	.5	96.4
27.00	4	.5	96.8
28.00	3	.4	97.2
29.00	4	.5	97.7
30.00	7	.8	98.5
31.00	1	.1	98.6
32.00	2	.2	98.8
35.00	2	.2	99.1
36.00	1	.1	99.2
38.00	2	.2	99.4
40.00	1	.1	99.5
42.00	1	.1	99.6
43.00	1	.1	99.8
44.00	1	.1	99.9
45.00	1	.1	100.0
Total	855	100.0	

Hierarchical Multivariate Regression Analysis

The data were subjected to a hierarchical multivariate linear regression with the dependent variable =length of stay and independent variables = all other variables. This allowed for a complete analysis of all variables and the extent to which the variation in length of stay was influenced by each ($N = 855$, $d_f = (8)$). Upon evaluation of the original equation containing 217 variables (see appendix A), 13 were significant ($p < .05$) and were assessed in a second iteration regression. These variables are shown in table 2.

Table 2. Variables significant at $p < .05$ after first regression

Variable	Coding Method	Variable Type
Prior Renal Transplant	1=yes, 0=otherwise	Binary
No HLA mismatches	1=yes, 0=otherwise	Binary
ICU admission	1=yes, 0=otherwise	Binary
AB Center	1=yes, 0=otherwise	Binary
AZ Center	1=yes, 0=otherwise	Binary
CN Center	1=yes, 0=otherwise	Binary
GU Center	1=yes, 0=otherwise	Binary
KY Center	1=yes, 0=otherwise	Binary
VA Center	1=yes, 0=otherwise	Binary
Peripheral Vascular Disease	1=yes, 0=otherwise	Binary
Ganciclovir 1st 24 hrs	1=yes, 0=otherwise	Binary
Donor Source	1=Cadevaric organ, 0=otherwise	Binary
Total Cold Time	In minutes	Continuous

Table 3. Descriptive statistics from the variables significant at $p < .05$ after the first regression

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
AB Center	.04	.18	855
AZ center	.01	.10	855
CN Center	.01	.11	855
1=Cadevaric organ, 0=otherwise	.72	.45	855
GANC1	.20	.40	855
GU Center	.02	.13	855
No HLA mismatches	.15	.36	855
ICU admission 1=yes, 0=no	.05	.21	855
KY Center	.03	.18	855
PRI_TRAN	.15	.35	855
PVD	.06	.23	855
Total Cold Ischemia Time	1098.67	716.74	855
VA Center	.02	.15	855

It is apparent from the first set of descriptive statistics contained in table 3 that the binary variables give us very little descriptive information. What they do provide is the percentage of the data set that applies to that variable. For example the

.mean of 02 for the VA transplant center indicates that 2 percent of the cases originated from that transplant center. In addition 15 percent of the sample had previous transplants, 72 percent were cadevaric donations and only five percent were automatically admitted to the ICU post op. The standard deviations of the binary variables are not useful in this analysis.

The mean and standard deviations for the length of stay indicate that the mean was 10.6 days and that the first standard deviation (comprising 68 percent of the cases) went from 4 - 16 days. Ninety-five percent of the cases (two standard deviations) were from 0 - 22 days. While it seems unlikely that there was a zero day stay post transplant, three are recorded in the sample all from separate locations. The wide standard deviation leads one to believe that even with the size of the sample and the central limit theorem, the sample is still quite disbursed.

Total cold ischemic time is also rather widely disbursed around the mean of 18 hours with the first standard deviation ranging from 6 - 30 hours. This results in 95 percent of the organs in ice solution from five (the minimum) to 42 hours.

Table 4 contains the results of the first regression analysis. Comparing the initial results with the working hypotheses, it appears that the variables *no HLA mismatches, immediate graft function in the OR and total OR time* were not significant in this sample. *Total cold ischemic time, transplant centers, ICU stay post transplant* and *prior transplant experience* were significant. Other variables were significant and are also contained in table 4. A strong positive relationship exists among the variables (.496 with 1.0 being a perfect one-to-one correlation) and nearly 25 percent of the unique variation in length of stay accounted for by these variables.

The second regression was performed with just the variables that were significant from the first regression. The variables are listed in table 5. The descriptive statistics are of course the same as previously mentioned. The model summary changed slightly but not appreciably. The unique variance accounted for dropped by about one percent and the standard error of the estimate increased by .1. This seems to indicate that the previous model was fairly close to the final model when it comes to how the independent variables influenced length of stay.

One variable, *total cold storage time*, was deleted from the original equation due to its collinearity with the *total cold ischemic time* variable.

Collinearity is defined as two independent variables which are highly correlated with one another. This causes both variables to provide similar information and no additional unique variation upon statistical manipulation. The problem becomes more complicated when the researcher cannot determine the separate effects of each variable (Norusis 1995). One of the variables is then excluded from the model because it can cause computational confusion and does not account for additional unique variation in the model. Reevaluation of the original data showed that there were two variables so similar as to be seen as equal to SPSS. When *total cold time* was eliminated from the data set, *total cold ischemic time* became statistically significant and was added to the final equation.

Table 4. Summary of the first regression model results

Model Summary[a,b]

Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
VA Center, Total Cold Ischemia Time, KY Center, PVD, GU Center, No HLA mismatches, 1=Cadevaric organ, 0=otherwise, AZ center, ICU admission 1=yes, 0=no, AB Center, PRI_TRAN, CN Center, GANC1[c,d]	.	.496	.246	.235	5.7881

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), VA Center, Total Cold Ischemia Time, KY Center, PVD, GU Center, No HLA mismatches, 1=Cadevaric organ, 0=otherwise, AZ center, ICU admission 1=yes, 0=no, AB Center, PRI_TRAN, CN Center, GANC1

d. All requested variables entered.

Table 5. Variables significant at $p < .05$ after the second regression, which comprise the final model

Variable	Coding Method	Variable Type
Prior Renal Transplant	1=yes, 0=otherwise	Binary
ICU admission	1=yes, 0=otherwise	Binary
AB Center	1=yes, 0=otherwise	Binary
AZ Center	1=yes, 0=otherwise	Binary
CN Center	1=yes, 0=otherwise	Binary
GU Center	1=yes, 0=otherwise	Binary
KY Center	1=yes, 0=otherwise	Binary
VA Center	1=yes, 0=otherwise	Binary
Total Cold Time	In minutes	Continuous

Table 6. Descriptive Statistics for the final regression model

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay Days	10.64	6.62	855
AB Center	3.51E-02	.18	855
AZ center	1.05E-02	.10	855
CN Center	1.29E-02	.11	855
GU Center	1.64E-02	.13	855
ICU admission 1=yes, 0=no	4.80E-02	.21	855
KY Center	3.39E-02	.18	855
PRI_TRAN	.15	.35	855
Total Cold Ischemia Time	1098.67	716.74	855
VA Center	2.22E-02	.15	855

Table 7. Summary of the final regression model

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	td. Error of the Estimate
1	VA Center, Tota Cold Ischemia Time, KY Center, AZ cente GU Center, AB Center, ICU admission 1=yes, 0=no, PRI_TRAN, CN Center[c,d]	.	.486	.236	.228	5.8120

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), VA Center, Total Cold Ischemia Time, KY Center, AZ center, GU Center, AB Center, ICU admission 1=yes, 0=no, PRI_TRAN, CN Center

d. All requested variables entered.

While holding all others constant, each variable in the final model was evaluated for its *unique* contribution to the variation in LOS. This was done by using the equation:

$$F = \frac{r^2_{full} - r^2_{restricted} \,/\, NLIPV_f - NLIPV_r}{(1 - r^2_{full}) \,/\, (n - NLIPV_f)}$$

This method resulted in the findings of table 8. Upon deletion of all variables which did not show significance at $p < .05$, in the prior regression analysis, the final equation describing the factors which contributed the most to the variance of length of stay in renal transplantation was:

$y = a_o u + b_1$ centers $+ b_2$ ICU admission $+ b_3$ prior transplant $+ b_4$ total cold ischemic time

Table 8. Final regression model unique variation contributions

Effect Tested	r^2_{full}	$r^2_{reduced}$	Unique Variance	df_1	df_2	F	p
Full model	.230	N/A	.230	0	9	28.07	.000
*Centers	.230	.111	.119	3	9	21.79	.000
ICU Admission	.230	.179	.051	8	9	56.03	.000
Prior transplant	.230	.222	.008	8	9	8.78	.000
Total cold ischemic time	.230	.198	.032	8	9	35.16	.000

*Centers contains six discrete variables: AB, AZ, CN, GU, KY, VA

After seeing the largest amount of unique variation attributed to the transplantation center, a multivariate regression was performed on the centers against length of stay.

Table 9. Descriptive statistics of transplant centers vs. length of stay in days

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
AB Center	.04	.18	855
AR Center	.02	.12	855
AZ center	.01	.10	855
BG Center	.02	.14	855
CN Center	.01	.11	855
CO Center	.03	.16	855
FR Center	.05	.21	855
GA Center	.03	.18	855
GU Center	.02	.13	855
HR Center	.05	.23	855
IA Center	.04	.18	855
IN Center	.04	.19	855
KS Center	.03	.18	855
KY Center	.03	.18	855
MN Center	.05	.23	855
MV Center	.01	.11	855
OH Center	.02	.14	855
PA Center	.05	.21	855
SB Center	.02	.15	855
SC Center	.06	.24	855
SH Center	.07	.26	855
ST Center	.03	.17	855
UC Center	.04	.20	855
UT Center	.04	.18	855
VA Center	.02	.15	855
VB Center	.02	.14	855
WI Center	.05	.22	855
YN Center	.02	.15	855

Table 10. Model summary of transplant center vs. length of stay in days[a]

Model	Variables Entered	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	YN Center, AZ center, MV Center, CN Center, AR Ce GU Center, VB Center, O Center, BG Center, VA Center, SB Center, CO Cen ST Center, KS Center, KY Center, GA Center, UT Center, IA Center, AB Cent IN Center, UC Center, PA Center, FR Center, WI Cen HR Center, MN Center , S Center, SH Center[c,d]	.475	.226	.199	5.9196

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), YN Center, AZ center, MV Center, CN Center, AR Center, VB Center, OH Center, BG Center, VA Center, SB Center, CO Center, ST Ce Center, KY Center, GA Center, UT Center, IA Center, AB Center, IN Center, UC Ce Center, FR Center, WI Center, HR Center, MN Center , SC Center, SH Center

d. All requested variables entered.

The results of the analysis of the centers against LOS, implies the presence of regional variation. It does not provide any indication of a reason for the apparent regional difference. Further studies need to investigate this possible regional variation.

Appendix C provides some of the same tables from this section along with additional detail not presented here. The detailed tables and simple regression graphs give further indications of the direction and magnitude of the relationships found through the regression analysis.

DISCUSSION AND RECOMMENDATIONS

Two hundred thousand people have chronic renal disease and 11,000 will receive a renal transplant this year. Renal transplants cost the national medical care system a billion dollars per year and the length of the hospital stay is the best predictor of the total cost of each transplant. Determining the variables which contribute to the overall LOS will allow medical care system to concentrate on that variable in an effort to bring down LOS while maintaining the quality of care.

Of the 264 variables originally collected, there were four variables that contributed the most to the unique variation in renal transplant LOS. These were total cold ischemic time, prior transplant experience, center of transplant and ICU admission post surgery. Of the four variables, three appear to be within the administrative control of the institution performing the surgery.

Total Cold Ischemic Time

Total cold ischemic time, ICU admission post transplant, and prior transplant screening are variables that each center can address. In this study it was demonstrated that the total cold ischemic time uniquely accounts for 3.2 percent of the total variability in renal transplant LOS ($p < .000$). In this sample, increasing the cold ischemic time was positively correlated with LOS. This would indicate that patients and transplant centers would benefit from processes that help to lower cold ischemic time. These findings add to the body of literature *in favor* of lowering cold ischemic times. In conversation with transplant specialists and coordinators, they are split on whether they think that cold ischemic time makes a difference in the transplant experience. Given the exact probability from the simple regression $p < .00000000000163$, we can say with some assurance (though not definitively nor implying cause and effect) that this relationship did not occur by chance and that the relationship does exist.

Routine Intensive Care Unit Admission

This sample aptly demonstrates that internal processes and clinical pathways that routinely utilize intensive care unit capabilities post transplant surgery incur increased LOS leading to additional cost to the patient and center. The indiscriminate use of these expensive limited resources should yield to the use

of active clinical judgment. Intensive care resources should be confined to patients who demonstrate *clinical necessity.* Clinicians and administrators should work toward developing specific clinical pathways which separate patients by severity post surgery. This division would allow for new processes to be developed that would decrease the *routine* utilization of ICU resources.

Georgetown still admits straight to the ICU post transplant which it is due to the intensity of the patient and skill mix required As noted in the results section, only five percent of the cases in the 1995 data set were routinely admitted to the ICU. This leads one to believe that routinely admitting the ICU post operatively is not part of the required national standard of care. The only restriction then appears to stem from staffing requirements. There are no unique instrumentation requirements that the surgical unit does not have. The intensity of the patient care issues come from the monitoring of the urine chemistry and vital signs. These may be accomplished on the surgical unit given the proper staffing ratios. While only five percent of the unique variation is accounted for through routine ICU admission, only five percent of the sample was admitted to the ICU. The ratio between the percentage admitted to the ICU and unique

variation accounted for is striking and bears watching. The routine use of the ICU post operatively should be avoided unless clinically necessary.

Prior Renal Transplant Experience

Within this sample, prior transplant experience appears to account for less than one percent of the variation in renal transplant LOS. Patients should be screened for prior transplantation and the clinical staff should concentrate additional resources to combat rejection or other comorbidities that may have led to the new transplant. It would seem to be judicious for centers to develop unique clinical pathways for these individuals that take into account their experience with the pre / post surgical routine and drug regimens. Further studies should explore the patient demographics, i.e. education, health status, and social support that differentiate these patients from the first-time transplant patient.

Transplantation Center

Transplantation center accounts for largest part of the unique variation in LOS and are the least controllable elements in the aggregate. While there are national transplant conferences and meetings, there does not appear to be a standard LOS. In researching clinical guidelines and pathways for this project, a transplant center in the mid-west who had a very low LOS (four days) was asked

for a copy of their clinical pathway. While Georgetown is not in regional competition with the center, the transplant coordinator had to *get permission* from hospital administration and the transplant surgeon. This indicates that each transplant center must devise their own pathway through trail and error which is particularly inefficient and adds to the national cost of transplants. It is like trying to find your way across country without a map. You may find your way, but it will take much longer than if you had a map. Collaboration is the only way to form a national standard of care that will bring down the overall cost to the medical care system. If all centers have a *map* then research can concentrate on honing the pathway rather having to find their way.

Due to the constraints of the data set, little can be *concluded* about regional variation. Several centers data were incomplete and were excluded from the study for reliability sake. There are strong indications that further study into regional variation would yield national cost savings. It appears clear that future collaboration would decrease the effects of regional variation.

There is still a lot of research to be done in length of stay for all types of transplantation surgery. The literature is *thin* on the subject was initiated for

cost reduction rather than quality of care. Special attention should be given to clinical staff (see figure 2, the conceptual model) and especially clinical pathways.

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Appendix A

List of Study Variables with Descriptions

Original Data Set Variables and Coding Methods

Variable	Coding Method	Variable Type
Age	Age in years	Continuous
[2,3]Prior Renal Transplant	1=yes, 0=otherwise	Binary
Donor Age	Age in Years	Continuous
Cold Storage Time	Time in Minutes	Continuous
Time Organ on Pump	Time in Minutes	Continuous
Total Cold Ischemia Time	Time in Minutes	Continuous
[2]No HLA mismatches	1=yes, 0=otherwise	Binary
1 HLA mismatch	1=yes, 0=otherwise	Binary
2 HLA mismatches	1=yes, 0=otherwise	Binary
3 HLA mismatches	1=yes, 0=otherwise	Binary
4 HLA mismatches	1=yes, 0=otherwise	Binary
5 HLA mismatches	1=yes, 0=otherwise	Binary
6 HLA mismatches	1=yes, 0=otherwise	Binary
Time in Recovery	Time in Minutes	Continuous
[2,3]ICU admission	1=yes, 0=otherwise	Binary
[2,3]AB Center	1=yes, 0=otherwise	Binary
AR Center	1=yes, 0=otherwise	Binary
[2,3]AZ Center	1=yes, 0=otherwise	Binary
BG Center	1=yes, 0=otherwise	Binary
[2,3]CN Center	1=yes, 0=otherwise	Binary
CO Center	1=yes, 0=otherwise	Binary
FR Center	1=yes, 0=otherwise	Binary

Note: First model contained all variables,

[2] Second model contained these shaded variables which were significant at ($p<.05$).

[3] Final model contained these shaded variables which were significant at ($p<.05$).

Variable	Coding Method	Variable Type
GA Center	1=yes, 0=otherwise	Binary
[2,3]GU Center	1=yes, 0=otherwise	Binary
HR Center	1=yes, 0=otherwise	Binary
IA Center	1=yes, 0=otherwise	Binary
IN Center	1=yes, 0=otherwise	Binary
KS Center	1=yes, 0=otherwise	Binary
[2,3]KY Center	1=yes, 0=otherwise	Binary
LA Center	1=yes, 0=otherwise	Binary
MN Center	1=yes, 0=otherwise	Binary
MV Center	1=yes, 0=otherwise	Binary
NE Center	1=yes, 0=otherwise	Binary
OH Center	1=yes, 0=otherwise	Binary
PA Center	1=yes, 0=otherwise	Binary
SB Center	1=yes, 0=otherwise	Binary
SC Center	1=yes, 0=otherwise	Binary
SH Center	1=yes, 0=otherwise	Binary
ST Center	1=yes, 0=otherwise	Binary
TJ Center	1=yes, 0=otherwise	Binary
UC Center	1=yes, 0=otherwise	Binary
UT Center	1=yes, 0=otherwise	Binary
[2,3]VA Center	1=yes, 0=otherwise	Binary
VB Center	1=yes, 0=otherwise	Binary
WI Center	1=yes, 0=otherwise	Binary
YN Center	1=yes, 0=otherwise	Binary
Recipient Gender	1=female, 0=male	Binary

Note: First model contained all variables,

[2] Second model contained these shaded variables which were significant at ($p<.05$).

[3] Final model contained these shaded variables which were significant at ($p<.05$).

Variable	Coding Method	Variable Type
Type I Diabetes	1=yes, 0= otherwise	Binary
Type II Diabetes	1=yes, 0= otherwise	Binary
Smoking History	1=yes, 0=otherwise	Binary
Smoking Currently	1=yes, 0=otherwise	Binary
Prior Blood Transfusion	1=yes, 0=otherwise	Binary
Cardiac Disease	1=yes, 0=otherwise	Binary
[2]Peripheral Vascular Disease	1=yes, 0=otherwise	Binary

Drug Protocols

Azathioprine Day of Surgery	1=yes, 0=otherwise	Binary
Azathioprine 1st 24 hrs	1=yes, 0=otherwise	Binary
Azathioprine 2nd 24 hrs	1=yes, 0=otherwise	Binary
Cyclosporine Day of Surgery	1=yes, 0=otherwise	Binary
Cyclosporine 1st 24 hrs	1=yes, 0=otherwise	Binary
Cyclosporine 2nd 24 hrs	1=yes, 0=otherwise	Binary
Antithrombocyte Day of Surgery	1=yes, 0=otherwise	Binary
Antithrombocyte 1st 24 hrs	1=yes, 0=otherwise	Binary
Antithrombocyte 2nd 24 hrs	1=yes, 0=otherwise	Binary
Muromonab CD3 Day of Surgery	1=yes, 0=otherwise	Binary
Muromonab CD3 1st 24 hrs	1=yes, 0=otherwise	Binary
Muromonab CD3 2nd 24 hrs	1=yes, 0=otherwise	Binary
Glucocorticoids Day of Surgery	1=yes, 0=otherwise	Binary
Glucocorticoids 1st 24 hrs	1=yes, 0=otherwise	Binary
Glucocorticoids 2nd 24 hrs	1=yes, 0=otherwise	Binary
Tacrolimus Day of Surgery	1=yes, 0=otherwise	Binary

Note: First model contained all variables,

[2] Second model contained these shaded variables which were significant at ($p<.05$).

[3] Final model contained these shaded variables which were significant at ($p<.05$).

Variable	Coding Method	Variable Type
Tacrolimus 1st 24 hrs	1=yes, 0=otherwise	Binary
Tacrolimus 2nd 24 hrs	1=yes, 0=otherwise	Binary
Acyclovir Day of Surgery	1=yes, 0=otherwise	Binary
Acyclovir 1st 24 hrs	1=yes, 0=otherwise	Binary
Acyclovir 2nd 24 hrs	1=yes, 0=otherwise	Binary
Ganciclovir Day of Surgery	1=yes, 0=otherwise	Binary
[2]Ganciclovir 1st 24 hrs	1=yes, 0=otherwise	Binary
Ganciclovir 2nd 24 hrs	1=yes, 0=otherwise	Binary
Ketoconazole Day of Surgery	1=yes, 0=otherwise	Binary
Ketoconazole 1st 24 hrs	1=yes, 0=otherwise	Binary
Ketoconazole 2nd 24 hrs	1=yes, 0=otherwise	Binary
Fluconazole Day of Surgery	1=yes, 0=otherwise	Binary
Fluconazole 1st 24 hrs	1=yes, 0=otherwise	Binary
Fluconazole 2nd 24 hrs	1=yes, 0=otherwise	Binary
Mycophenalate Day of Surgery	1=yes, 0=otherwise	Binary
Mycophenalate 1st 24 hrs	1=yes, 0=otherwise	Binary
Mycophenalate 2nd 24 hrs	1=yes, 0=otherwise	Binary
Length of Stay	**In Days**	**Continuous**
Donor Source	1=Living related donor, 0=otherwise	Binary
Donor Source	1=Living unrelated, 0=otherwise	Binary
[2]Donor Source	1=Cadevaric organ, 0=otherwise	Binary
Donor Race	1=African American donor, 0=otherwise	Binary
Donor Race	1=Asian donor, 0=otherwise	Binary
Donor Race	1=Caucasian donor, 0=otherwise	Binary
Donor Race	1=Hispanic donor, 0=otherwise	Binary

Note: First model contained all variables,

[2] Second model contained these shaded variables which were significant at ($p<.05$).

[3] Final model contained these shaded variables which were significant at ($p<.05$).

Variable	Coding Method	Variable Type
Donor Race	1=Native American, 0=otherwise	Binary
Donor Race	1=not yet mentioned race, 0=otherwise	Binary
[2,3]Total Cold Time	In minutes	Continuous
Immediate Graft Function in OR	1=yes, 0=otherwise	Binary
Post OP Dialysis	1=yes, 0=otherwise	Binary
Rejection Episode	1=yes, 0=otherwise	Binary
Infection	1=yes, 0=otherwise	Binary
Complications	1=yes, 0=otherwise	Binary
Recipient Race	1=African American donor, 0=otherwise	Binary
Recipient Race	1=Asian donor, 0=otherwise	Binary
Recipient Race	1=Caucasian donor, 0=otherwise	Binary
Recipient Race	1=Hispanic donor, 0=otherwise	Binary
Recipient Race	1=Native American, 0=otherwise	Binary
Recipient Race	1=not yet mentioned race, 0=otherwise	Binary

Appendix B

Data Collection Questionnaire for the

University HealthSystem Consortium Renal Transplant Benchmarking Study

University Hospital Consortium Services Corporation
Clinical Process Improvement Program

Renal Transplantation Clinical Benchmarking
Data Collection Form

GENERAL GUIDELINES

(All data to be collected from consecutive cases in 1995)

1. Please use black ink and print information clearly. Make all characters recognizable and mark an "**X**" directly into check boxes. This fax will be transmitted into a new data fax program.
2. **All questions** are to be completed in order to accurately represent your clinical practices: If an item is **not applicable or unknown,** indicate this in the appropriate space and/or add a comment.
3. All time responses should be recorded using a 24-hour clock/military time.
4. All date responses should be recorded month/day/year (mm/dd/yy).
5. Before sending data collection forms to UHC, **check for completeness.**
6. For data collection purposes, the **Encounter Number** should be the numbers that identify the patient's current admission. At some institutions, this may be a date code. This is a number or code that changes with each admission to the health care center.
7. The **Unique Patient I.D. Number** (assigned by your institution for data submission to UHC's Clinical Information Network) is often the patient's account number or all/part of the medical record number as it is defined locally. This code number will not change.
8. To locate the correct **Clinical Information Network (CIN)** code numbers described in #6 and #7, contact the CIN Liaison at your institution. Please call if you need to know who your liaison is.
9. Each participant is required to assign consecutive numbers to each data collection form (DCF) submitted. The first case completed is given number | 0 | 0 | 1 | ; the second case is assigned number | 0 | 0 | 2 | .
10. Please retain the original data collection forms for your records.
11. Thank you for your participation in this project.

If you have any questions, call Helen Kallimani at (708) 954-1707.

Clinical Projects Coordinator
University Hospital Consortium
2001 Spring Road, Suite 700
Oak Brook, IL 60521-1890

PLEASE FAX COMPLETED DATA COLLECTION FORMS TO (708) 954-6015.

 Institution Name: _____ **Case No.** | | | |

THE UNIVERSITY HOSPITAL CONSORTIUM SERVICES CORPORATION
RENAL TRANSPLANT DATABASE

A. ADMINISTRATIVE DATA

1. Encounter Number | | | | | | | | | | | | | | | |

2. Unique Patient *CIN* ID Number | | | | | | | | | | | | | | | |

3. Social Security Number *(needed to link with UNOS follow-up data)* | | | | - | | | - | | | | |

B. INCLUSION CRITERIA

1. Kidney (ONLY) Transplant (Age ≥ 17)
   ☐ Yes

2. On Research Protocol
   ☐ Yes, Drug Type _____
   ☐ Yes, Device Type _____
   ☐ No

C. DEMOGRAPHIC DATA

1. Date of Birth _____ / _____ / _____ (MM / DD / YY)

2. Age (≥ 17) _____ years

3a. Admit Date _____ / _____ / _____ (MM / DD / YY)

3b. Admit Time _____:_____ (military time)

4. Gender
   ☐ Female
   ☐ Male

5. Transplant _____ / _____ / _____ (MM / DD / YY)

6. Hospital Discharge _____ / _____ / _____ (MM / DD / YY)

7. Date of Death _____ / _____ / _____ (MM / DD / YY)
   ☐ N/A

8. Race
   ☐ African American
   ☐ Asian
   ☐ Caucasian
   ☐ Hispanic
   ☐ Native American
   ☐ Other (specify): _____

 Institution Name: _____ **Case No.** | | | |

D. CLINICAL PRESENTATION

1. Past Medical History of Recipient (check all that apply)
   - ☐ Type I Diabetes (Juvenile Onset)
   - ☐ Type II Diabetes
   - ☐ Smoking Hx, Pack Years _____ (Pack Years = packs per day X no. of yrs. smoked)
   - ☐ Smoking Hx, Pack Years Unknown
   - ☐ Current Smoker (at time of admission)
   - ☐ Prior Blood Transfusions
   - ☐ Cardiac Disease (CAD, Valves, previous revascularization procedures)
   - ☐ Peripheral Vascular Disease (PVD)
   - ☐ Other (specify): _____

2. Total number of months on dialysis* during patient's lifetime:

   _____ months

   *Include hemodialysis, peritoneal dialysis, or ultrafiltration.

3. Is this a Re-Transplant? (whether same side or opposite side)
   - ☐ Yes (complete question 3a.)
   - ☐ No

3a. If yes, number of prior kidney transplants:

_____ transplants

E. PREPARATION FOR TRANSPLANT

1. Medications [check the drugs the patient received on the day of surgery (DOS), during the 1st 24 hours post-op, and during the 2nd 24 hours post-op (hours 25-48)]:

	DOS	1st 24 hrs	2nd 24 hrs
• Azathioprine/AZA (Imuran)	☐	☐	☐
• Cyclosporine/CSA (Sandimmune)	☐	☐	☐
• Antithymocyte Globulin (Atgam/ATG)	☐	☐	☐
• Muromonab CD3 (Orthoclone OKT-3)	☐	☐	☐
• Glucocorticoids (Prednisone, Solumed)	☐	☐	☐
• Tacrolimus (FK-506, Prograf)	☐	☐	☐
• Acyclovir (Zovirax)	☐	☐	☐
• Ganciclovir (DHPG, Cytovene)	☐	☐	☐
• Ketoconazole (Nizoral)	☐	☐	☐
• Fluconazole (Diflucan)	☐	☐	☐
• Mycophenalate Mofetil	☐	☐	☐

 Institution Name: _____ **Case No.** ☐☐☐

2. Tests and/or procedures done *after* admission, but *before* surgery: (check all that apply)
   - ☐ CXR
   - ☐ EKG
   - ☐ Dialysis
   - ☐ Nephrology consult
   - ☐ Cardiology consult
   - ☐ Other (specify): _____

3. The patient was admitted to the following location for *preoperative* work-up: (check one)
   - ☐ Emergency Department
   - ☐ Ambulatory Surgery
   - ☐ ICU
   - ☐ Routine Unit
   - ☐ Operating Room
   - ☐ Other (specify): _____

4. Was a Central Venous Catheter placed preoperatively?
   - ☐ Yes
   - ☐ No

5. Was an Arterial Line placed preoperatively?
   - ☐ Yes
   - ☐ No

F. KEY DONOR AND ORGAN DATA

1. UNOS I.D. Number _ _ _ _ _ _

2. Donor Age _____ years

3. Donor Source
   - ☐ Living Related
   - ☐ Living Unrelated
   - ☐ Cadaveric

4. Donor Race
   - ☐ African American
   - ☐ Asian
   - ☐ Caucasian
   - ☐ Hispanic
   - ☐ Native American
   - ☐ Other (specify): _____

5. Cold Storage (from time preservation begins to time organ removed from cold storage; do not include pump time)
   ☐ N/A _____ hours _____ minutes

6. Time Organ on Pump (pulsatile perfusion)
   ☐ N/A _____ hours _____ minutes

7. Total Cold Ischemia Time ("pump" + "cold storage")
   ☐ N/A _____ hours _____ minutes

8. Anastomotic Time (from time cold storage ends until reperfusion in recipient begins)
   _____ minutes

 Institution Name: _____ **Case No.** | | | |

9. HLA Tissue Typing Data
Donor/Recipient mis-matches
- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6

10a. Peak (Highest) Panel Reactive Antibody (PRA)
- ☐ 0 - 20%
- ☐ 21 - 60%
- ☐ 61 -100%

10b. Current (at admission) Panel Reactive Antibody (PRA)
- ☐ 0 - 20%
- ☐ 21 - 60%
- ☐ 61 -100%

11. Recipient CMV (Cytomegalovirus) Status
- ☐ Positive
- ☐ Negative

12. Donor CMV (Cytomegalovirus) Status
- ☐ Positive
- ☐ Negative

13. Recipient HCV (Hepatitis C Virus) Status
- ☐ Positive
- ☐ Negative

14. Donor HCV (Hepatitis C Virus) Status
- ☐ Positive
- ☐ Negative

G. KEY SURGICAL FACTORS

1. Operating Room Times (military time)
- Patient enters operating room ___:___ (where procedure is performed)
- Anesthesia induction ___:___ (time anesthetic administered)
- Incision time ___:___
- Closure ___:___
- Patient leaves operating room ___:___ (where procedure is performed)

2. Immediate Graft Function* (in OR)?
- ☐ Yes
- ☐ No

* Enter "Yes" if graft functions immediately after clamp release.

3. Was patient extubated in OR?
- ☐ Yes
- ☐ No (complete questions 3a., 3b.)

3a. Date of Extubation
_____ / _____ / _____
MM DD YY

3b. Time of Extubation
____:____ (military time)

4. Return to OR this admission?
- ☐ No Return to OR
- ☐ Open Biopsy
- ☐ Transplant Nephrectomy (choose one)
  - ☐ Thrombosis
  - ☐ Rejection
  - ☐ Other (specify): _____
- ☐ CAPD Catheter Removal
- ☐ Ureter Dysfunction/Leak
- ☐ Other (specify): _____

 Institution Name: _____ **Case No.** | | | |

5. Did patient go to the recovery room/PACU? ☐ Yes (complete question 5a.) ☐ No 5a. Length of Time in Recovery _____ hours _____ minutes	6. Unplanned admission/return to ICU? ☐ Yes (complete questions 6a., 6b., 6c.) ☐ No 6a. Specify reason for unplanned admit/return: _____ 6b. ICU Admission Date ____ / ____ / ____ MM DD YY 6c. ICU Discharge Date ____ / ____ / ____ MM DD YY
7. Please select the type of unit that best describes the patient disposition immediately postoperatively and/or post recovery (choose one): ☐ ICU ☐ Specialized Unit: Transplant, Renal, Urology ☐ Medical/Surgical ☐ Other	7a. In the chosen unit, what is the level of care that the patient received during the first 12-24 hours postoperatively: ☐ Patient received intensive (ICU) level of care (nurse/patient ratio approximately 1:1, 1:2) ☐ Patient received intermediate [step down] level of care (nurse/patient ratio approximately 1:3, 1:4) ☐ Patient received routine level of care (nurse/patient ratio 1:5 or greater)

 Institution Name: _____ **Case No.** | | | |

H. KEY POSTOPERATIVE FACTORS

1. Number of Labs/Tests Performed *Postoperatively* until Hospital Discharge

	No. of Labs
• Chemistry Profile (SMA 6, 7, 12, 24, etc.)	_____
• CBC with Platelets (with or without differential)	_____
• PT/INR	_____
• aPTT	_____
• BUN (not in a panel)	_____
• Creatinine (not in a panel)	_____
• Glucose (not in a panel)	_____
• Cyclosporine Level	_____
• Amylase	_____
• Viral Titers	_____
• T-Lymph Subset	_____
• FK-506 Level	_____
• Renal Biopsy - needle	_____
• Renal Biopsy - surgery	_____
• Ultrasound (without doppler)	_____
• Doppler Ultrasound	_____
• Flow Scan (Tc Scan)	_____
• CXR	_____
• EKG	_____
• ABO Type & Crossmatch	_____
• ABO Type & Screen	_____
• Urinalysis	_____
• Urine Culture	_____
• 24th Creatinine Clearance	_____
• Other (specify): _____	

2. Blood products received postoperatively* (after patient leaves OR until discharge)

- ☐ None
- ☐ RBCs _____ units
- ☐ Platelets _____ units
- ☐ FFP _____ units
- ☐ Albumin _____ ml
- ☐ Other (specify): _____

* Include blood products given in recovery room/PACU.

3. Post Transplant Dialysis? (hemodialysis, peritoneal dialysis, or ultrafiltration)

- ☐ Yes (complete questions 3a., 3b.)
- ☐ No

3a. Reason for Dialysis

- ☐ Rejection
- ☐ Delayed Graft Function/ Acute Tubular Necrosis
- ☐ Other (specify): _____

3b. Number of Dialysis Treatments Administered Postoperatively

_____ treatments

 Institution Name: _____ **Case No.** [ ][ ][ ]

I. POSTOPERATIVE COMPLICATIONS - as documented in the medical record

1. Rejection episodes during this admission?
   - ☐ Yes (complete questions 1a., 1b.)
   - ☐ No

1a. Additional Drugs Used (check all that apply) Record only drugs administered to treat the rejection episode. Do not include drugs the patient was taking prior to this rejection episode.
   - ☐ Solumedrol
   - ☐ Increasing dose of oral steroids
   - ☐ Azathioprine/AZA (Imuran)
   - ☐ Cyclosporine/CSA (Sandimmune)
   - ☐ Antithymocyte globulin (Atgam/ATG)
   - ☐ Muromonab CD3 (Orthoclone OKT-3)
   - ☐ Tacrolimus (FK-506, Prograf)
   - ☐ Other (specify): _____

1b. Was a renal biopsy done to confirm rejection?
   - ☐ Yes
   - ☐ No

2. Infection (check all that apply)
   - ☐ None
   - ☐ Urinary Tract Infection Requiring Treatment
     - ☐ PO medications
     - ☐ IV medications
     - ☐ Other (specify): _____
   - ☐ Clinical Sepsis (fever of unknown origin, hypotension, oliguria, negative blood culture)
   - ☐ Intra-abdominal (includes gallbladder, spleen, liver, pancreas, peritoneum, etc.)
   - ☐ GI Tract (includes esophagus, stomach, small & large bowel, and rectum)
   - ☐ Lab-determined bloodstream (positive blood culture)
   - ☐ Pneumonia (positive CXR, positive sputum, or rales)
   - ☐ Surgical Site: Superficial Incision (involves only skin and sub-Q tissue; if fascia or muscle also infected, select deep incision)
   - ☐ Surgical Site: Deep Incision (involves fascia and muscle layers)
   - ☐ Surgical Site: Organ Space (involves any tissue surgically opened/manipulated but excludes skin, fascia, and muscle)
   - ☐ Other (specify): _____

3. Complications - excluding infections (check all that apply)
   - ☐ None
   - ☐ Nephrotoxicity (drug induced)
   - ☐ New Onset Hypertension (diagnosed this admission)
   - ☐ CHF/Pulmonary Edema
   - ☐ Respiratory Failure (requiring ventilation support)
   - ☐ Acute Myocardial Infarction
   - ☐ Stroke (deficits persisting > 24 hours)
   - ☐ Pancreatitis
   - ☐ Graft Thrombosis
   - ☐ Other (specify): _____

 Institution Name: _____ Case No. [ ][ ][ ]

J. KEY DISCHARGE FACTORS

1. Patient Status at Discharge

- ☐ Patient alive, graft functioning
- ☐ Patient alive, graft failure
- ☐ Patient death, graft functioning
- ☐ Patient death, graft failure

2. Medications at Discharge

- ☐ Solumedrol
- ☐ Prednisone
- ☐ Azathioprine/AZA (Imuran)
- ☐ Cyclosporine/CSA (Sandimmune)
- ☐ Tacrolimus (FK-506, Prograf)
- ☐ Acyclovir
- ☐ Ganciclovir
- ☐ Antithymocyte globulin (Atgam/ATG)
- ☐ Muromonab CD3 (Orthoclone OKT-3)
- ☐ Ketoconazole
- ☐ Fluconazole
- ☐ Mycophenalate Mofetil
- ☐ Other **Immunosuppressives** (specify):

_____

3. How many antihypertensives (including diuretics) were prescribed at discharge?

- ☐ None
- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four
- ☐ Five or more

4. Patient Discharge Disposition

- ☐ Home without professional care
- ☐ Home with professional care (VNA)
- ☐ Rehabilitation facility (patients with disabilities)
- ☐ Transfer to another acute care center
- ☐ Skilled Nursing Facility (convalescent or restorative care provided)
- ☐ Nursing Home (long term custodial support with medical/nursing care provided)
- ☐ Hotel
- ☐ Other (specify): _____

Appendix C

Detailed Regression Tables and Simple Regression Plots

Table of Contents for Appendix C
Detailed Regression Tables and Simple Regression Plots

Appendix C Explanations

Appendix C contains the detailed results of all regression analyses.

Descriptive Statistics: Mean, standard deviation and number of cases.

Model Summary: Variables which entered the regression model, R and R^2 (unique variation accounted for by the model variables), adjusted R^2 and standard error of the estimate (the distance of the estimate to the actual observation along the regression line).

ANOVA Table : Contains the sum of squares (or sum of the squared deviations from the regression line to the actual observations), degrees of freedom, mean squared error, F and the significance of the F result. The significance is reported to three decimal places

tables, correlation tables, ANOVA tables and graphs (except for multivariate analyses) for the final hierarchical regression model. The first section contains the hierarchical multivariate analysis of the final model variables verses length of stay in days. The next section attempts to investigate the effect of regional variation by looking at whether the transplant was done at a specific center verses the length of stay in days. While this is not a perfect proxy, it gives us an indication that regional variation may exist.

The remaining sections take a detailed look at each of the individual variables against length of stay in days. These sections also have simple regression graphs. These graphs each have a line of best fit accompanied by a horizontal line which represents the mean of the observations. For the variables that represent the centers of transplant, the observations are 1=yes (the transplant occurred at the center) or 0=no (the transplant occurred at another center.

Multivariate Linear Regression: Final Model

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
AB Center	3.51E-02	.18	855
AZ center	1.05E-02	.10	855
CN Center	1.29E-02	.11	855
GU Center	1.64E-02	.13	855
ICU admission 1=yes, 0=no	4.80E-02	.21	855
KY Center	3.39E-02	.18	855
PRI_TRAN	.15	.35	855
Total Cold Ischemia Time	1098.67	716.74	855
VA Center	2.22E-02	.15	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	VA Center, Total Cold Ischemia Time, KY Center, AZ center, GU Center, AB Center, ICU admission 1=yes, 0=no, PRI_TRAN, CN Center[c,d]	.	.486	.236	.228	5.8120

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), VA Center, Total Cold Ischemia Time, KY Center, AZ center, GU Center, AB Center, ICU admission 1=yes, 0=no, PRI_TRAN, CN Center

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8839.62	9	982.180	29.077	.000[b]
	Residual	28543.15	845	33.779		
	Total	37382.77	854			

a. Dependent Variable: Length of Stay in Days

b. Independent Variables: (Constant), VA Center, Total Cold Ischemia Time, KY Center, AZ center, GU Center, AB Center, ICU admission 1=yes, 0=no, PRI_TRAN, CN Center

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	7.22	.38		19.10	.000
	AB Center	6.74	1.09	.19	6.20	.000
	AZ center	4.99	1.95	.08	2.56	.011
	CN Center	7.58	1.79	.13	4.24	.000
	GU Center	5.56	1.57	.11	3.54	.000
	ICU admission 1=yes, 0=no	7.38	.94	.24	7.88	.000
	KY Center	7.58	1.10	.21	6.88	.000
	PRI_TRAN	1.78	.57	.09	3.13	.002
	Total Cold Ischemia Time	.00	.00	.19	6.29	.000
	VA Center	5.12	1.35	.11	3.78	.000

a. Dependent Variable: Length of Stay in Days

Multivariate Regression of Length of Stay in Days Vs. Centers

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
AB Center	.04	.18	855
AR Center	.02	.12	855
AZ center	.01	.10	855
BG Center	.02	.14	855
CN Center	.01	.11	855
CO Center	.03	.16	855
FR Center	.05	.21	855
GA Center	.03	.18	855
GU Center	.02	.13	855
HR Center	.05	.23	855
IA Center	.04	.18	855
IN Center	.04	.19	855
KS Center	.03	.18	855
KY Center	.03	.18	855
MN Center	.05	.23	855
MV Center	.01	.11	855
OH Center	.02	.14	855
PA Center	.05	.21	855
SB Center	.02	.15	855
SC Center	.06	.24	855
SH Center	.07	.26	855
ST Center	.03	.17	855
UC Center	.04	.20	855
UT Center	.04	.18	855
VA Center	.02	.15	855
VB Center	.02	.14	855
WI Center	.05	.22	855
YN Center	.02	.15	855

Table 10. Model summary of transplant center vs. length of stay in days[a,b]

Model	Variables Entered	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	YN Center, AZ center, MV Center, CN Center, AR Center, GU Center, VB Center, OH Center, BG Center, VA Center, SB Center, CO Center, ST Center, KS Center, KY Center, GA Center, UT Center, IA Center, AB Center, IN Center, UC Center, PA Center, FR Center, WI Center, HR Center, MN Center , SC Center, SH Center[c,d]	.475	.226	.199	5.9196

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), YN Center, AZ center, MV Center, CN Center, AR Center, GU Center, VB Center, OH Center, BG Center, VA Center, SB Center, CO Center, ST Center, KS Center, KY Center, GA Center, UT Center, IA Center, AB Center, IN Center, UC Center, PA Center, FR Center, WI Center, HR Center, MN Center , SC Center, SH Center

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8438.00	28	301.36	8.60	.000[b]
	Residual	28944.77	826	35.04		
	Total	37382.77	854			

a. Dependent Variable: Length of Stay in Days

b. Independent Variables: (Constant), YN Center, AZ center, MV Center, CN Center, AR Center, GU Center, VB Center, OH Center, BG Center, VA Center, SB Center, CO Center, ST Center, KS Center, KY Center, GA Center, UT Center, IA Center, AB Center, IN Center, UC Center, PA Center, FR Center, WI Center, HR Center, MN Center , SC Center, SH Center

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.71	.72		14.91	.000
	AB Center	5.13	1.30	.14	3.95	.000
	AR Center	-2.55	1.79	-.05	-1.42	.155
	AZ center	3.85	2.10	.06	1.83	.067
	BG Center	-4.33	1.64	-.09	-2.63	.009
	CN Center	8.11	1.92	.14	4.22	.000
	CO Center	-4.25	1.45	-.10	-2.93	.004
	FR Center	-.49	1.17	-.02	-.42	.678
	GA Center	-.40	1.31	-.01	-.30	.763
	GU Center	4.65	1.74	.09	2.68	.008
	HR Center	-2.55	1.13	-.09	-2.26	.024
	IA Center	.09	1.30	.00	.07	.942
	IN Center	.36	1.27	.01	.28	.779
	KS Center	1.22	1.33	.03	.92	.358
	KY Center	7.29	1.31	.20	5.56	.000
	MN Center	2.57	1.12	.09	2.29	.022
	MV Center	-.89	1.92	-.02	-.46	.645
	OH Center	-1.96	1.64	-.04	-1.19	.235
	PA Center	-3.94	1.19	-.12	-3.31	.001
	SB Center	3.03	1.54	.07	1.97	.049
	SC Center	-3.72	1.08	-.14	-3.45	.001
	SH Center	-1.88	1.04	-.07	-1.81	.070
	ST Center	-2.13	1.36	-.06	-1.56	.119
	UC Center	-2.40	1.22	-.07	-1.97	.049
	UT Center	-2.01	1.30	-.06	-1.55	.122
	VA Center	4.87	1.54	.11	3.17	.002
	VB Center	-1.89	1.64	-.04	-1.15	.250
	WI Center	4.13	1.16	.13	3.55	.000
	YN Center	-.66	1.51	-.01	-.44	.663

a. Dependent Variable: Length of Stay in Days

Simple Regression of
Length of Stay in Days vs. AB Transplant Center

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
AB Center	.04	.18	855

Correlations

		Length of Stay in Days	AB Center
Pearson Correlation	Length of Stay in Days	1.000	.150
	AB Center	.150	1.000
Sig. (1-tailed)	Length of Stay in Days	.	.000
	AB Center	.000	.
N	Length of Stay in Days	855	855
	AB Center	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	AB Center[c,d]	.	.150	.022	.021	6.5454

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), AB Center

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	838.24	1	838.24	19.566	.000[b]
	Residual	36544.53	853	42.84		
	Total	37382.77	854			

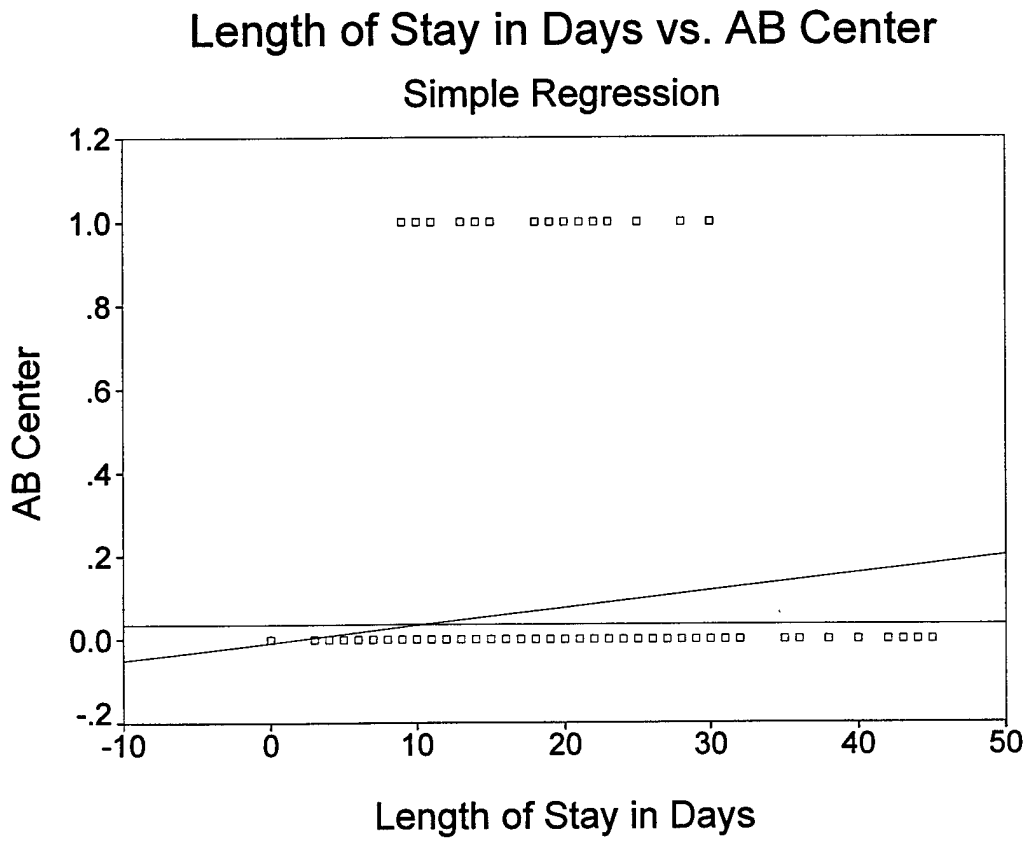
a. Dependent Variable: Length of Stay in Days

b. Independent Variables: (Constant), AB Center

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.45	.23		45.87	.00
	AB Center	5.38	1.22	.15	4.42	.00

a. Dependent Variable: Length of Stay in Days



Simple Regression of
Length of Stay in Days vs. AZ Transplant Center

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
AZ center	.01	.10	855

Correlations

		Length of Stay in Days	AZ center
Pearson Correlation	Length of Stay in Days	1.000	.061
	AZ center	.061	1.000
Sig. (1-tailed)	Length of Stay in Days	.	.037
	AZ center	.037	.
N	Length of Stay in Days	855	855
	AZ center	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	AZ center[c,d]	.	.06	.00	.00	6.61

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), AZ center

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	139.39	1	139.39	3.192	.074[b]
	Residual	37243.38	853	43.66		
	Total	37382.77	854			

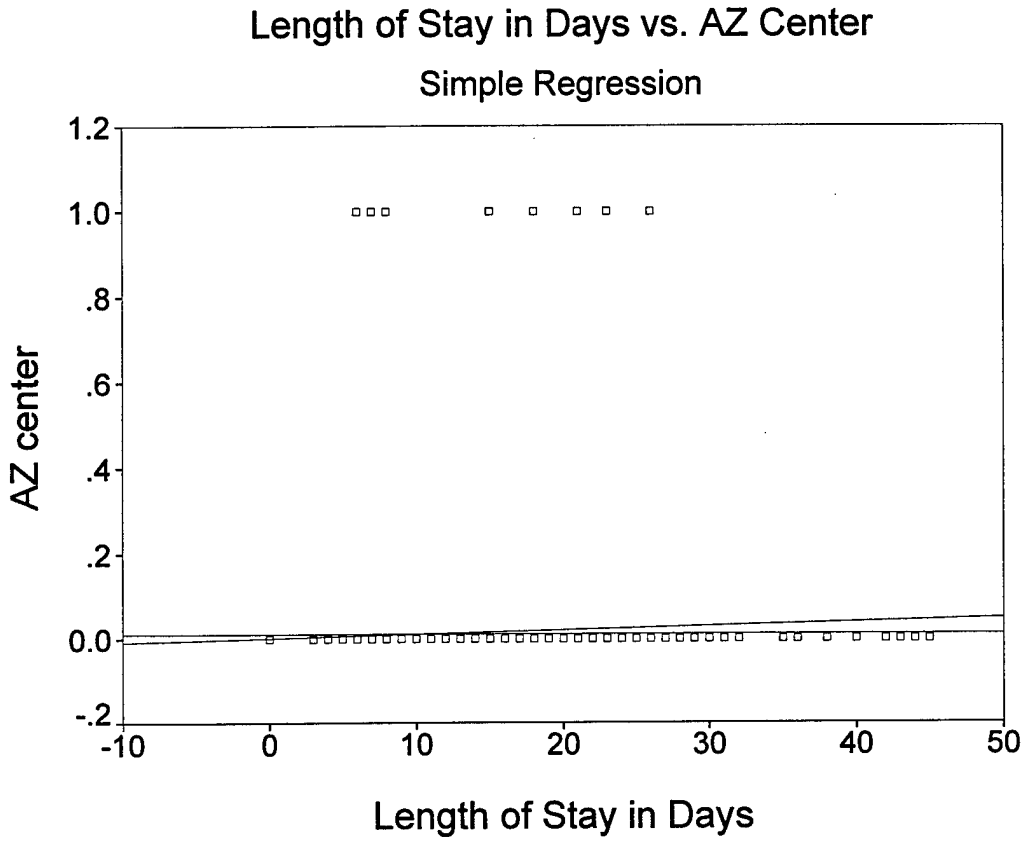
a. Dependent Variable: Length of Stay in Days

b. Independent Variables: (Constant), AZ center

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.60	.23		46.66	.000
	AZ center	3.96	2.21	.06	1.79	.074

a. Dependent Variable: Length of Stay in Days



Simple Regression of
Length of Stay in Days vs. CN Transplant Center

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
CN Center	1.29E-02	.11	855

Correlations

		Length of Stay in Days	CN Center
Pearson Correlation	Length of Stay in Days	1.000	.141
	CN Center	.141	1.000
Sig. (1-tailed)	Length of Stay in Days	.	.000
	CN Center	.000	.
N	Length of Stay in Days	855	855
	CN Center	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	CN Center[c,d]	.	.141	.020	.019	6.5537

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), CN Center

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	745.13	1	745.13	17.348	.000[b]
	Residual	36637.64	853	42.95		
	Total	37382.77	854			

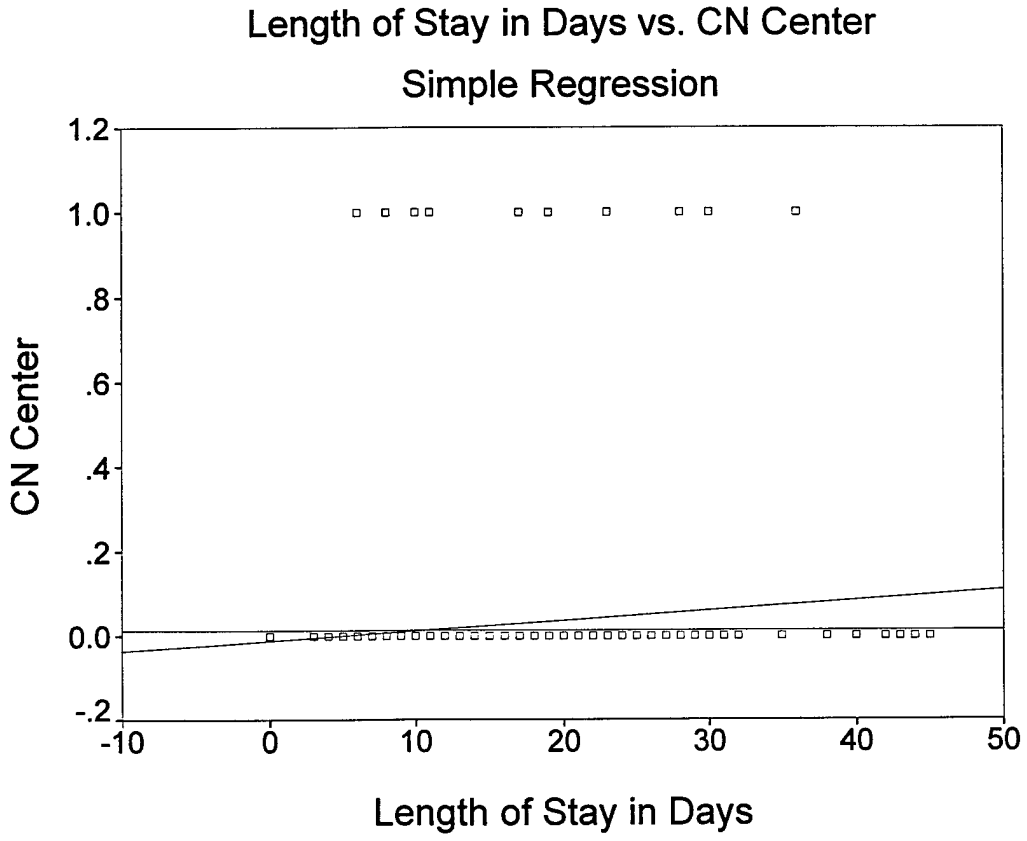
a. Dependent Variable: Length of Stay in Days

b. Independent Variables: (Constant), CN Center

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.53	.23		46.697	.000
	CN Center	8.28	1.99	.14	4.165	.000

a. Dependent Variable: Length of Stay in Days



Simple Regression of Length of Stay in Days vs. GU Transplant Center

Descriptive Statistics

	Mean	Std. Deviation	N
Length of Stay in Days	10.64	6.62	855
GU Center	.02	.13	855

Correlations

		Length of Stay in Days	GU Center
Pearson Correlation	Length of Stay in Days	1.000	.092
	GU Center	.092	1.000
Sig. (1-tailed)	Length of Stay in Days	.	.004
	GU Center	.004	.
N	Length of Stay in Days	855	855
	GU Center	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	GU Center[c,]	.	.092	.008	.007	6.59

a. Dependent Variable: Length of Stay in Days

b. Method: Enter

c. Independent Variables: (Constant), GU Center

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	316.58	1	316.58	7.285	.007[b]
	Residual	37066.19	853	43.45		
	Total	37382.77	854			

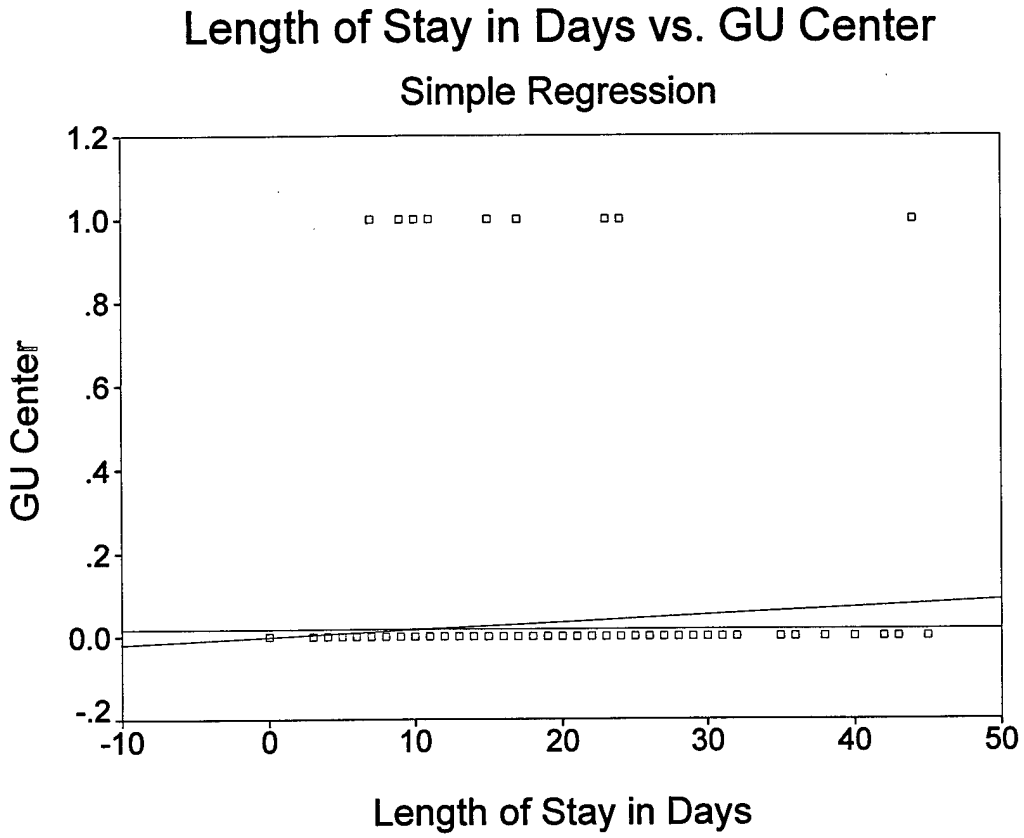
a. Dependent Variable: Length of Stay in Days

b. Independent Variables: (Constant), GU Center

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.56	.23		46.47	.000
	GU Center	4.79	1.78	.09	2.70	.007

a. Dependent Variable: Length of Stay in Days



Simple Regression of
Length of Stay in Days vs. KY Transplant Center

Descriptive Statistics

	Mean	Std. Deviation	N
KY Center	.03	.18	855
Length of Stay in Days	10.64	6.62	855

Correlations

		KY Center	Length of Stay in Days
Pearson Correlation	KY Center	1.000	.209
	Length of Stay in Days	.209	1.000
Sig. (1-tailed)	KY Center	.	.000
	Length of Stay in Days	.000	.
N	KY Center	855	855
	Length of Stay in Days	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	Length of Stay in Days[c,d]	.	.209	.043	.042	.1772

a. Dependent Variable: KY Center

b. Method: Enter

c. Independent Variables: (Constant), Length of Stay in Days

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.22	1	1.22	38.781	.000[b]
	Residual	26.80	853	.03		
	Total	28.02	854			

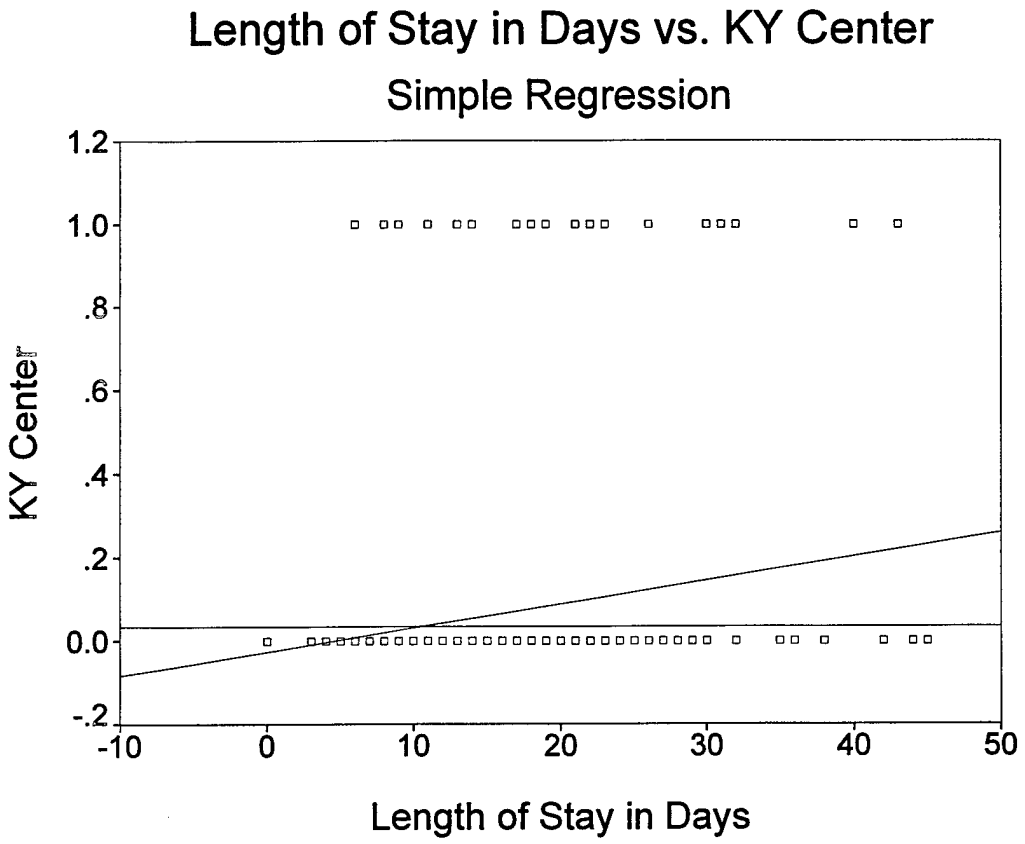
a. Dependent Variable: KY Center

b. Independent Variables: (Constant), Length of Stay in Days

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.03	.01		-2.336	.020
	Length of Stay in Days	.01	.00	.21	6.227	.000

a. Dependent Variable: KY Center



Simple Regression of Length of Stay in Days vs. VA Transplant Center

Descriptive Statistics

	Mean	Std. Deviation	N
VA Center	.02	.15	855
Length of Stay in Days	10.64	6.62	855

Correlations

		VA Center	Length of Stay in Days
Pearson Correlation	VA Center	1.000	.113
	Length of Stay in Days	.113	1.000
Sig. (1-tailed)	VA Center	.	.000
	Length of Stay in Days	.000	.
N	VA Center	855	855
	Length of Stay in Days	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	Length of Stay in Days[c,d]	.	.113	.013	.012	.15

a. Dependent Variable: VA Center

b. Method: Enter

c. Independent Variables: (Constant), Length of Stay in Days

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.24	1	.24	10.951	.001[b]
	Residual	18.34	853	.02	1	.235
	Total	18.58	854	18.34	853	2.150E-02

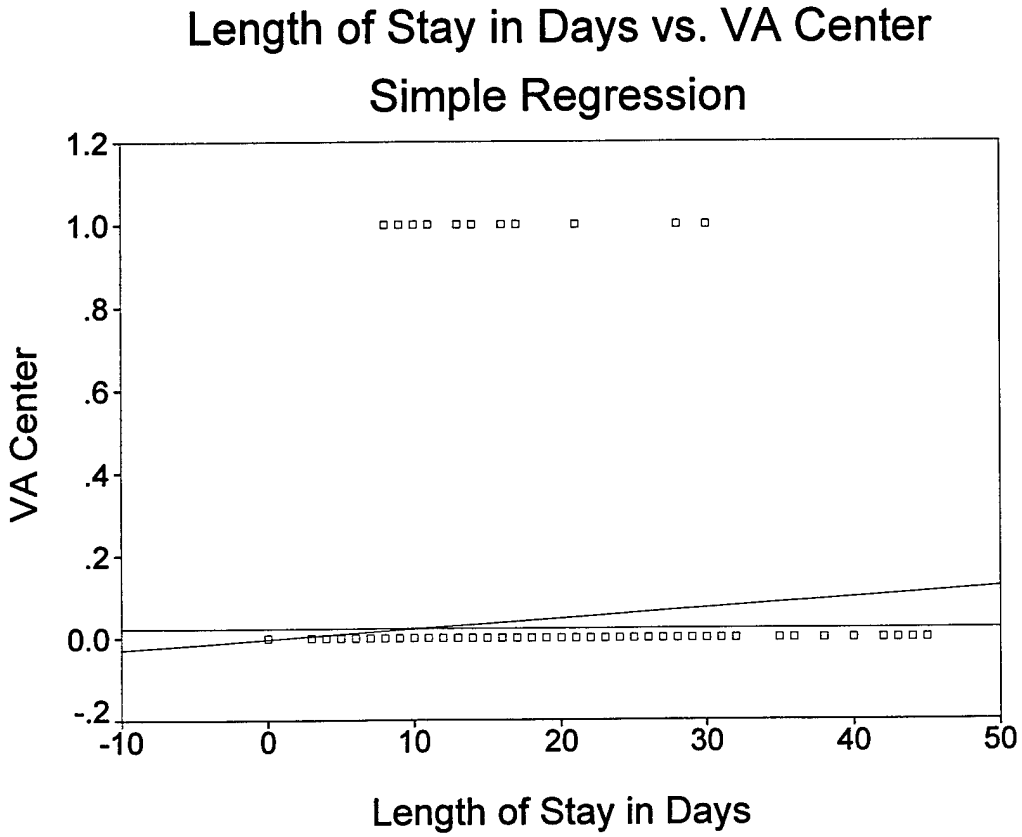
a. Dependent Variable: VA Center

b. Independent Variables: (Constant), Length of Stay in Days

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.00	.010		-.472	.637
	Length of Stay in Days	.00	.001	.113	3.309	.001

a. Dependent Variable: VA Center



Simple Regression of
Length of Stay in Days vs. Prior Transplant Experience

Descriptive Statistics

	Mean	Std. Deviation	N
PRI_TRAN	.15	.35	855
Length of Stay in Days	10.64	6.62	855

Correlations

		PRI_TRAN	Length of Stay in Days
Pearson Correlation	PRI_TRAN	1.000	.130
	Length of Stay in Days	.130	1.000
Sig. (1-tailed)	PRI_TRAN	.	.000
	Length of Stay in Days	.000	.
N	PRI_TRAN	855	855
	Length of Stay in Days	855	855

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	Length of Stay in Days[c,d]	.	.130	.017	.016	.3496

a. Dependent Variable: PRI_TRAN

b. Method: Enter

c. Independent Variables: (Constant), Length of Stay in Days

d. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.79	1	1.79	14.632	.000[b]
	Residual	104.23	853	.12		
	Total	106.02	854			

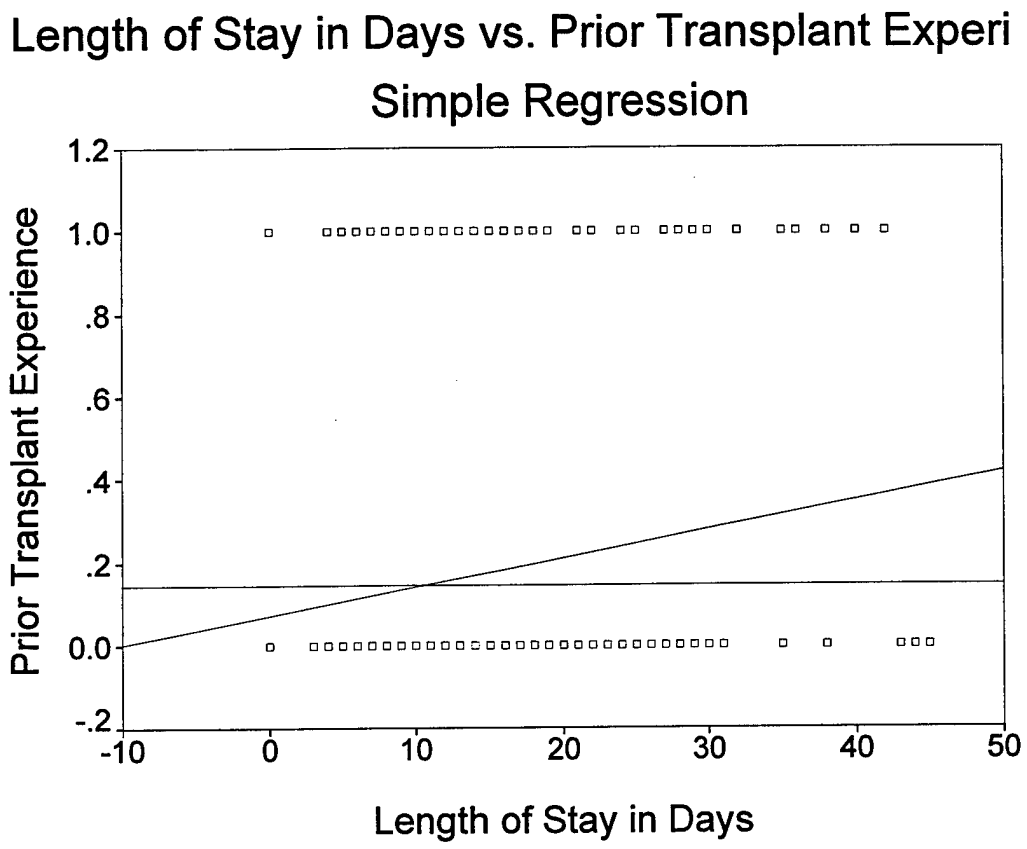
a. Dependent Variable: PRI_TRAN

b. Independent Variables: (Constant), Length of Stay in Days

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.07	.02		3.154	.002
	Length of Stay in Days	.01	.00	.13	3.825	.000

a. Dependent Variable: PRI_TRAN



Simple Regression of
Length of Stay in Days vs. Total Cold Ischemia Time

Descriptive Statistics

	Mean	Std. Deviation	N
Total Cold Ischemia Time	1098.67	716.74	855
Length of Stay in Days	10.64	6.62	855

Correlations

		Total Cold Ischemia Time	Length of Stay in Days
Pearson Correlation	Total Cold Ischemia Time	1.000	.234
	Length of Stay in Days	.234	1.000
Sig. (1-tailed)	Total Cold Ischemia Time	.	.000
	Length of Stay in Days	.000	.
N	Total Cold Ischemia Time	855	855
	Length of Stay in Days	855	855

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23962912	1	23962912	49.284	.000[b]
	Residual	414746422	853	486220.89		
	Total	438709335	854			

a. Dependent Variable: Total Cold Ischemia Time

b. Independent Variables: (Constant), Length of Stay in Days

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	Length of Stay in Days[c,d]	.	.234	.055	.054	697.30

a. Dependent Variable: Total Cold Ischemia Time

b. Method: Enter

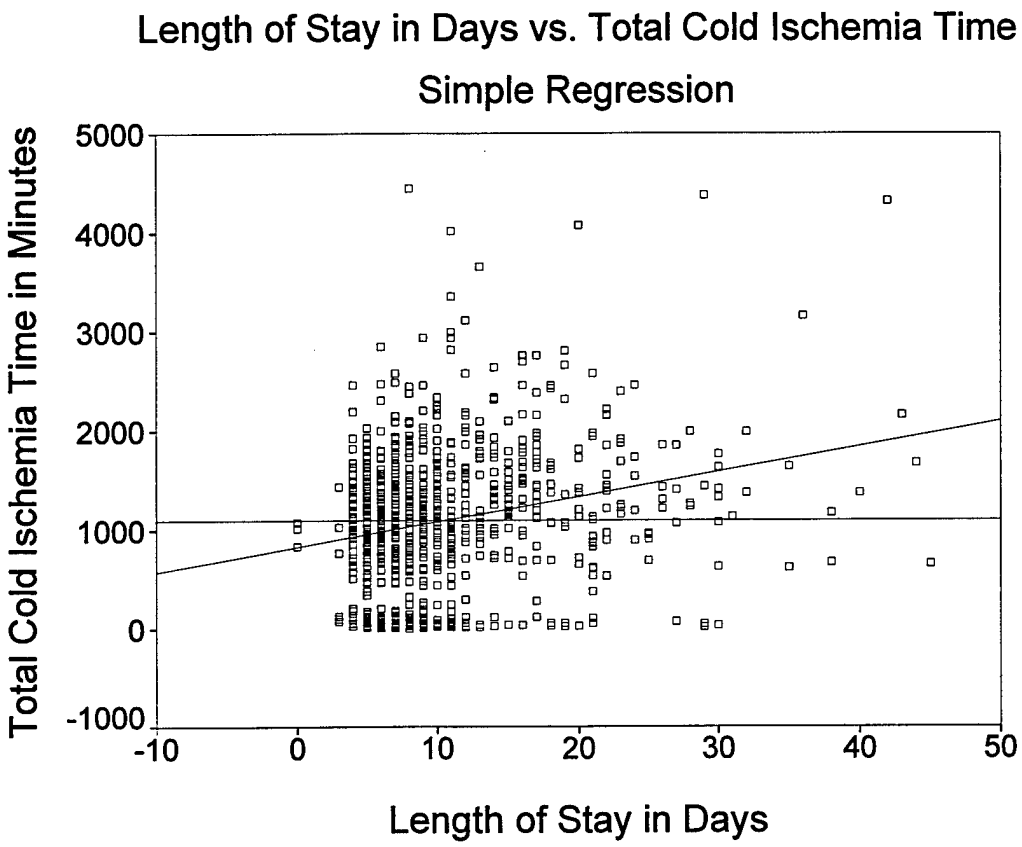
c. Independent Variables: (Constant), Length of Stay in Days

d. All requested variables entered.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	829.26	45.18		18.354	.000
	Length of Stay in Days	25.32	3.61	.23	7.020	.000

a. Dependent Variable: Total Cold Ischemia Time



Results of the First Regression Calculation

Appendix D

Georgetown University Hospital
Renal Transplant Clinical Pathway

GEORGETOWN UNIVERSITY HOSPITAL
CLINICAL PATHWAY - ADULT KIDNEY TRANSPLANT RECIPIENT (HOSPITALIZATION)

	Admission - Pre-Op SICU	Day 0 Intra-Op	Day 0 Post-Op SICU	POD 1 SICU	POD 2 6 Main	POD 3 6 Main	POD 4 6 Main	POD 5 6 Main	POD 6 6 Main	POD 7-10 6 Main	Discharge 6 Main
NOTIFY	House Officer Nephrologist			Renal: Social Worker Dietitian							Complete Discharge Checklist
TESTS	Chem 20 (then Q Mon) Stat Chem 7 PT PTT B_2M CBC w/Diff Retic Ct. (then Q Mon) Type & Cross 2U. PRBC's HLA Cxm bld if requested by txp. coordinator Call HLA tech to pick-up after drawn. Check that final report is in the chart before going to the O.R. CAD Txp: Stat EKG Stat CXR PA & Lat. LRD Txp: EKG CXR PA & Lat.	LRD Txp: 5A pre-op Stat Chem 7	Stat CBC w/Diff Stat Chem 7, then (not stat) Chem 7 Q 12° X 2 PT (then Q Mon) PTT(then Q Mon) Activated T Cells CXR (portable)	CBC w/Diff QD → Chem 7 (QD except Mon) → B_2M QD → CyA Level QD → Renal Scan if oliguric			Stool Guaiac QD →				U/A Urine C&S Complete Discharge Checklist

	Admission - Pre-Op SICU	Day 0 Intra-Op	Day 0 Post-Op SICU	POD 1 SICU	POD 2 6 Main	POD 3 6 Main	POD 4 6 Main	Pod 5 6 Main	POD 6 6 Main	POD 7-10 6 Main	Discharge 6 Main
T R E A T M E N T S	VS on admission then Q 8° and prior to O.R. (No BP or IV on vascular access extremity) I & O Q 8° Check for allergies Weight SSE til clear Hibiclens shower (contact w/skin & hair x 5 min before rinsing) PAS stockings Consents for: Cadaveric or living donor renal txp by Drs. Alijani/ Romolo Admin of blood and/or blood products Dialysis PRN		VS Q 15 mins X 4 then Q 30 min X 2 then Q 1° X 24 hrs (increase HOB 30° once BP is stable) Temp Q 4° CVP Q 1° CV catheter care Q 8° I & O Q 1° If UOP is < 200 cc/hr, replace cc/cc + 20 cc/hr with (D5 1/2 NS) If UOP is > 200 cc/hr, replace cc/cc: 50% R/L, 50% D5 1/2 NS Notify H.O. if UOP is < 50 cc or > 400/hr D/C Dextrose Soln. Weight Strict handwashing Mask Isolation Incentive spirometer Q 30 min while awake Hibiclens bath Foley catheter to closed drainage Foley catheter care Q 8° PAS stockings Vascular access pre-cautions	VS (including temp) Q 4° CVP Q 4° I & O Q 4° (If on ATG, OKT3 or IV Steroids)	D/C I & O Q 8°	VS (including temp) Q 8° D/C	D/C D/C D/C			D/C - When	Cath D/C'd Hibiclens shower day 11 to D/C

	Admission Pre-Op SICU	Day 0 Intra-Op	DAY 0 Post-op SICU	POD 1 SICU	POD 2 6 Main	POD 3 6 Main	POD 4 6 Main	POD 5 6 Main	POD 6 6 Main	POD 7-10 6 Main	Discharge 6 Main
MEDICATIONS	**CAD & LRD:** Acyclovir 800mg. po x 1 **LRD Txp:** CyA 5 mg/kg Po Bid Prednisone 0.5mg/kg or 30 mg po x 1 - which ever is less	Initiation of Surgery: Solumedrol 125mg IV push Ancef 1 gm IV push (if not allergic) Imuran 200mg IV push (4mg/kg or 200mg–which-ever is less) Crystalloid to maintain CVP of 10-12 cms Dopamine Drip 2-3 mcgms/kg/min FFP if pt. had dialysis within the last 4-6 hrs. Just before clamp release: Solumedrol 125mg IV push Lasix 80mg IV push Mannitol 12.5gms IV push (repeat Q 30 mins x 4 doses total) SPA (25% sol'n) 12.5 gms IV push (repeat Q 30 min x 4 doses total) Verapamil 5mg IV (if needed per the txp surgeon and anesthesiologist) If no UOP within first hr. begin: Lasix drip (Lasix 250mg in 250ml D_5W) at 20mg (20ml) per hr.	**CAD Txp.** ATG or OKT3 Induction (7-14 doses) Solumedrol 50 mg IV Q 6^0 CyA IV 1mg/kg in 250 cc D_5W over 24^0 (hold if anuric) Azathioprine 1mg/kg IV in divided doses Bid (low dose if anuric) **LRD Txp:** Solumedrol IV (as above) CyA (as above) Azathiaprine 2mg/kg IV in divided doses Bid **All Patients:** Ancef IV 1 Gm IV Q 8^0 DHPG IV 2.5-5mg/kg Q 12^0 (7-14 days while on ATG or OKT3 depending on renal function) H_2O_2 (1/2 strength mouthwash) QID after meals & HS Nilstat 5 cc po swish/swallow Tid Pepcid 20 mg IV Bid B & O suppository 1 Q 4^0 prn for bladder spasm **Hx of + PPD/-CXR:** INH PO 300 mg QD for 1yr post-txp B_6 PO 50mg QD for 1 yr post-txp. **If + CMV Donor/-CMV Recipient** Cytogam 150mg/kg w/in 72 hrs 100mg/kg wks 2,4,6,8, 50mg/kg wks 12,16	(Refer to Immunosuppression Protocol) 50mg IV Q 8^0 1.5 mg/kg IV in 250cc D_5W over 24^0	50mg IV Q 12^0 2 mg/kg IV in 250 cc D_5W over 24^0	Prednisone 30 mg PO BiD CyA PO multiply last IV dose X3 give in divided doses BiD Azathiaprine PO Prednisone PO (as above) CyA PO (as above) Azathiaprine PO (as above) Bactrim PO (single strength QOD in ATN or QD w/good function) If unable to take Bactrim give Pentamidine 300mg inhalation 1 X per mo. X 6 mo. Acyclovir PO 800mg-3.2 Gms QD when DHPG is D/C'd. Continue 3 mo. post-d/c. Axid 150mg PO QD (stop when Prednisone is reduced to 10 mg QD $CaCo_3$ PO 650mg 2 w/meals TiD (if ATN) **All patients:** Persantine 5mg/Kg PO QD in 3 divided doses Stresstab 1 PO QD Peri-colace 1 PO QD				

	Admission SICU	Day 0 Intra-Op	Day 0 Post-op SICU	POD 1 SICU	POD 2 6 Main	POD 3 6 Main	POD 4 6 Main	POD 5 6 Main	POD 6 6 Main	POD 7-10 6 Main	Discharge 6 Main
ACTIVITY	Up Ad Lib	Bedrest →	May lie on back and txp side only →	→	OOB w/help	Up Ad Lib →	→	→	→	→	→
DIET	**CAD Txp:** NPO except for BP meds w/ sips of H_2O **LRD Txp:** Renal diet- pro 60gm/day K+ 60mEq/day No added salt Fluids cc/cc + 200cc Q 8° NPO after 12MN	NPO → LRD Txp: AM BP meds to be taken w/sips of H_2O	May take Nilstat PO →	→	Clear liquids as tolerated	Advance as tolerated If DGF, restrict: Na+ 2 Gms/day K+1 mEq/Kg/day Pro 1 Gm/Kg/day Fluids cc/cc +200-250cc Q 8°	Regular w/ Na+ Restricted to 2gms/ day →	→	→	→	→

	Admission SICU	Day 0 Intra-Op	Day 0 SICU	POD 1 SICU	POD 2 6 Main	POD 3 6 Main	Pod 4 6 Main	Pod 5 6 Main	Pod 6 6 Main	Pod 7-10 6 Main	Discharge 6 Main
PATIENT EDUCATION			Immediate Post-Op expectations	Mouth Care	Teach: Meaning of lab values Medication Administration Actions Dosages Side effects How to do and record I & O, need for fluid restriction PRN How to monitor for signs & symptoms of rejection and infection	Pt. Demonstrates: Knowledge of lab values Medication Administration Knowledge of: Actions Dosages Side effects How to do and record I & O, need for fluid restriction PRN How to monitor for signs & symptoms of rejection and infection	Pt. Demonstrates: Knowledge of lab values Medication Administration Knowledge of: Actions Dosages Side effects How to do and record I & O, need for fluid restriction PRN How to monitor for signs & symptoms of rejection and infection	Pt. Demonstrates: Knowledge of lab values Medication Administration Knowledge of: Actions Dosages Side effects How to do and record I & O, need for fluid restriction PRN How to monitor for signs & symptoms of rejection and infection	Alteration in ADL's	Alteration in ADL's	Complete D/C Checklist
DISCHARGE PLANNING	Nursing Assessment →	→	→	→	Follow-up: Social worker → Dietitian →	→	→	→	→	→	Complete D/C Checklist →

(Rev. 2/28/95)